

GROUNDWATER PROTECTION PROGRAM  
CALENDAR YEAR 1999  
EVALUATION OF GROUNDWATER QUALITY DATA  
FOR THE  
UPPER EAST FORK POPLAR CREEK HYDROGEOLOGIC REGIME  
AT THE  
U.S. DEPARTMENT OF ENERGY Y-12 PLANT,  
OAK RIDGE, TENNESSEE

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## List of Acronyms and Abbreviations

AJA	AJA Technical Services, Inc.
BCV	Bear Creek Valley
bgs	below ground surface
BT	buried tributary
CE	counting error
CFU/ml	colony forming units per milliliter
CY	calendar year
DNAPL	dense, nonaqueous phase liquids
DOE	U.S. Department of Energy
DQO	data quality objective
East Fork Regime	Upper East Fork Poplar Creek Hydrogeologic Regime
ft	feet
gpm	gallons per minute
GWMR	Groundwater Monitoring Report
GWPP	(Y-12 Plant) Groundwater Protection Program
LRSPW	Lake Reality Emergency Spillway (sampling station)
MCL	maximum contaminant level (for drinking water)
MDA	minimum detectable activity
mgd	million gallons per day
MIC	microbiologically induced corrosion
µg/L	micrograms per liter
mg/L	milligrams per liter
msl	mean sea level
mV	millivolts
NPDES	National Pollution Discharge Elimination System
OF	outfall (storm drain)
ORR	Oak Ridge Reservation
PCE	tetrachloroethene
pCi/L	picoCuries per liter
RCRA	Resource Conservation and Recovery Act
REDOX	oxidation-reduction potential
RI	Remedial Investigation
SAIC	Science Applications International Corporation
TCE	trichloroethene
UEFPC	Upper East Fork Poplar Creek
VOC	volatile organic compound
WCPA	Waste Coolant Processing Area
11DCA	1,1-dichloroethane
11DCE	1,1-dichloroethene
c12DCE	cis-1,2-dichloroethene
t12DCE	trans-1,2-dichloroethene
111TCA	1,1,1-trichloroethane
Tc-99	technetium-99
U-234	uranium-234
U-238	uranium-238



## 1.0 INTRODUCTION

This report presents an evaluation of the water quality monitoring data obtained by the Y-12 Plant Groundwater Protection Program (GWPP) in the Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork Regime) during calendar year (CY) 1999. The East Fork Regime contains many confirmed and potential sources of groundwater and surface water contamination associated with the U.S. Department of Energy (DOE) Oak Ridge Y-12 Plant. Applicable provisions of DOE Order 5400.1A - *General Environmental Protection Program* - require evaluation of groundwater and surface water quality near the Y-12 Plant to: (1) gauge groundwater quality in areas that are, or could be, affected by plant operations, (2) determine the quality of surface water and groundwater where contaminants are most likely to migrate beyond the DOE Oak Ridge Reservation (ORR) property line, and (3) identify and characterize long-term trends in groundwater quality at the Y-12 Plant. In addition to the groundwater and surface water quality data obtained by Lockheed Martin Energy Systems, Inc. specifically for the purposes of DOE Order 5400.1A, this evaluation incorporates CY 1999 monitoring results obtained by the Integrated Water Quality Program (managed by Bechtel Jacobs Company, LLC) for the purposes of: (1) Resource Conservation and Recovery Act (RCRA) post closure corrective action monitoring, as specified in the post closure permit for the Upper East Fork Poplar Creek Hydrogeologic Regime; and (2) Comprehensive Environmental Response, Compensation, and Liability Act remedial effectiveness monitoring, as specified in the applicable record of decision or decision documents pending final approval, and pre-remediation baseline water quality monitoring.

The following sections of this report contain relevant background information (Section 2.0); describe the results of the respective data evaluations required under DOE Order 5400.1A (Section 3.0); summarize significant findings of each evaluation (Section 4.0); and list the technical reports and regulatory documents cited for more detailed information (Section 5.0). Illustrations (maps and trend graphs) and tables referenced in each section are presented in Appendix A and Appendix B, respectively.



## **2.0 BACKGROUND INFORMATION**

The boundaries of the East Fork Regime, which encompass the main Y-12 Plant area in Bear Creek Valley (BCV), extend along the base of Pine Ridge to the north, the base of Chestnut Ridge to the south, the eastern boundary of the Bear Creek watershed to the west, and the ORR property line to the east (Figure 1). For the purposes of this report, the regime is divided into three major areas: the western plant area between the Bear Creek watershed boundary and Y-12 Plant grid coordinate easting 55,000, the central plant area between grid coordinate eastings 55,000 and 62,000, and the eastern plant area between grid coordinate easting 62,000 and the ORR property line (Figure 2). The following discussion provides brief descriptions of the geology and groundwater flow system in BCV, the contaminant source areas within the Y-12 Plant, and the extent of groundwater contamination in the East Fork Regime.

### **2.1 Topography and Bedrock Geology**

Ground elevations in BCV within the boundaries of the East Fork Regime range from about 1020 feet (ft) above mean sea level (msl) along the base of Pine Ridge and Chestnut Ridge in the Western plant area, to 900 ft msl along the axis of BCV in the exposed channel of Upper East Fork Poplar Creek (UEFPC) in the eastern plant area downstream of Lake Reality (Figure 2). Most of the regime is heavily industrialized and highly congested. A prominent local topographic feature is the gap in Pine Ridge cut by UEFPC northeast of the Y-12 Plant. This gap roughly corresponds with a less prominent divide in Chestnut Ridge to the southeast of the plant and may indicate some type of structural or stratigraphic discontinuity near Scarboro Road.

Alternating sequences of clastic and carbonate strata that form the distinctive topography of the Valley and Ridge Physiographic Province comprise the bedrock geology in the East Fork Regime. Shale and siltstone beds of the Rome Formation form Pine Ridge to the north, limestone and shale formations of the Conasauga Group form BCV, and the primarily dolostone formations of the Knox Group form Chestnut Ridge to the south (Figure 2). Strike and dip of bedding are generally N 55°E and 45°SE, respectively (as referenced to true north). Bedrock is overlain by up to 40 ft of several unconsolidated materials, including man-made fill, alluvium, colluvium, fine-grained residuum from the weathering of the bedrock, and saprolite (weathered bedrock). Where undisturbed, the saprolite often retains primary textural features of the unweathered bedrock, including fractures (Solomon *et al.* 1992).

Extensive cut-and-fill areas within the Y-12 Plant have substantially altered the shallow subsurface throughout much of the East Fork Regime (Figure 3). Most of the fill, which contains many voids and generally consists of a heterogeneous mixture of building debris and recompacted soil/residuum, was placed in the tributaries and main channel of UEFPC (Sutton and Field 1995). The numerous voids, heterogeneous composition, and varying thickness (5 to 25 ft) significantly influence shallow groundwater flow directions and contaminant migration patterns.

### **2.2 Surface Water System**

Surface water in the East Fork Regime is drained by UEFPC, which was extensively modified during construction of the Y-12 Plant. The headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central plant areas (Figure 3), were filled and replaced with an extensive network of underground storm drains. For reference purposes, each buried tributary (BT) of UEFPC is designated with a value (e.g., BT-1) representing the tributary number counted downstream (west to east) from the headwaters. Also, drainage patterns in the

eastern plant area were extensively modified during closure of New Hope Pond in 1988 and subsequent operation of Lake Reality. New Hope Pond was an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting the Y-12 Plant. Lake Reality, a lined surface impoundment built to replace New Hope Pond, began operation in 1988.

The underground network of storm drains in the western and central plant areas direct surface runoff into the exposed portion of the UEFPC channel at a number of outfalls. The westernmost extent of the exposed portion of the UEFPC channel is Outfall (OF) 200, located about 6000 ft upstream of New Hope Pond/Lake Reality (Figure 3). During normal operations, flow in UEFPC is directed through a concrete-lined distribution channel located around the south and east side of Lake Reality. Also, a gravel and perforated pipe underdrain beneath portions of the distribution channel captures shallow groundwater. Until December 1996 when a temporary siphon system was used to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was permanently diverted through the Lake Reality emergency spillway (LRSPW), which discharges into the mainstem of UEFPC directly north of Lake Reality. Bypassing Lake Reality reduces mercury contributions to dry-weather flow in UEFPC.

About 70% of dry-weather flow in UEFPC, excluding flow management, is attributable to once-through non-contact cooling water, condensate, and cooling tower blowdown, and the remaining 30% is from groundwater discharge (CDM Federal Programs Corporation 1994). Beginning in July 1996, raw water (i.e., Clinch River water from the intake lines to the DOE water treatment plant that supplies potable water to the Y-12 Plant, the Oak Ridge National Laboratory, and the City of Oak Ridge) has been discharged near OF 200 to augment flow in UEFPC, which decreased from 10-15 million gallons per day (mgd) to about 2.5 mgd because of reduced operations at the Y-12 Plant in recent years. Flow management is needed to achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17, where UEFPC exits the ORR downstream from Lake Reality. Flow management also allows compliance with NPDES toxicity requirements and helps lower the otherwise elevated water temperature in UEFPC.

### 2.3 Groundwater System

The following overview of the groundwater system in the East Fork Regime is based on the conceptual hydrogeologic models described in: *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE 1998), which is referenced hereafter as the Remedial Investigation (RI) report. This conceptual model incorporates: (1) the general hydrologic framework described in Solomon *et al.* (1992); (2) groundwater flow characteristics presented in Moore (1988 and 1989) and Moore and Toran (1992); (3) results of numerous hydrologic studies and investigations in BCV, including Dreier *et al.* (1987) and Shevenell (1994); and (4) findings of monitoring activities performed specifically for RI purposes (DOE 1998).

On the ORR in the vicinity of BCV, the Rome Formation, the Conasauga Group, and the Knox Group comprise two basic hydrogeologic units: (1) the aquifer, consisting of the Maynardville Limestone (upper Conasauga Group) and Knox Group, and (2) the aquitard, consisting of the remaining Conasauga Group formations (Nolichucky Shale, Maryville Limestone, Rogersville Shale, Rutledge Limestone, and Pumpkin Valley Shale) and the Rome Formation (Figure 2). The Maynardville Limestone functions as a hydrologic drain in BCV and provides the principal avenues for contaminant transport in the East Fork Regime. The aquitard formations underlie many of the contaminant source areas in the regime and are hydraulically upgradient of the aquifer.

Fractures provide the primary groundwater flowpaths in the aquitard and the aquifer, but dissolution of carbonates in the aquifer has enlarged fractures and produced solution cavities and conduits that greatly



enhance its hydraulic conductivity relative to the aquitard. Although negligible in both units, flow through the rock matrix plays an important role in contaminant migration because of matrix diffusion processes. Most of the flow in both units is primarily parallel to bedding (along strike and dip), which in the aquitard may or may not coincide with the direction of maximum horizontal hydraulic gradient inferred from groundwater elevation isopleths. In the aquitard, the bulk of flow is thought to occur within the shallow bedrock interval less than 70 ft below ground surface (bgs). Flow across bedding occurs primarily along permeable zones formed by cross-cutting fractures or fracture zones (and possibly small faults). Some of these cross-cutting structures may act as barriers to lateral flow, causing groundwater from deeper intervals to upwell and discharge to the shallower flow system in each hydrogeologic unit. Others may serve as preferential pathways for migration of contaminants from the aquitard into the aquifer.

Most groundwater flow in the aquifer is thought to occur at shallow depths, typically less than 100 ft bgs in an extensively interconnected karst network of solution conduits and cavities. Flow in the shallow karst network is relatively rapid, and during rainfall may occur as “quickflow” recharge/discharge toward springs or nearby surface drainage features (Shevenell 1994). Below the shallow karst network, fractures provide the primary flowpaths, and there are important lithologic controls on groundwater flow (Goldstrand 1995). Lithologic characteristics differentiate seven distinct stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone. The more permeable zones lie at the bottom (Zone 2) and top (Zone 6) of the formation (Shevenell *et al.* 1993). Because of vugular porosity related to dissolution of gypsum nodules, Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the Maynardville Limestone (Goldstrand 1995).

In both the western plant area and central plant area, groundwater generally flows south (across strike) from the aquitard toward the aquifer (Maynardville Limestone) and eastward along strike in the Maynardville Limestone toward the east end of the Y-12 Plant (Figure 4). However, the extensive network of basement dewatering sumps, storm drains, process lines, pipes, and outfalls in the shallow subsurface throughout much of the western and central plant areas strongly influences the movement and discharge of shallow groundwater, as well as the migration of groundwater contaminants. For instance, operation of sumps to suppress the local water table below the basement floor of Buildings 9204-4, 9201-5, and 9201-4, and possibly 9204-2 (Figure 3) strongly influences local groundwater flow and contaminant transport patterns (DOE 1998). In the eastern plant area, flow in the aquitard is more directly east (along strike) toward UEFPC, and flow in the aquifer is primarily to the east (along strike) toward Union Valley. However, groundwater flow directions at shallow depths in the Maynardville Limestone in the eastern plant area are strongly influenced by the UEFPC distribution channel underdrain, which apparently functions as a highly permeable groundwater flow path and a constant head (recharge) boundary (Science Applications International Corporation [SAIC] 1998). Additionally, operation of the Lake Reality Sump, which is a 6-ft diameter, 20-ft deep sump installed to reduce hydraulic pressure on the synthetic liner in Lake Reality, creates an elongated cone of depression in the aquitard (Nolichucky Shale) oriented parallel with strike and decreases water levels in the aquifer (Maynardville Limestone) along the main channel of UEFPC. The sump is activated manually as required (very infrequently) to reduce pressure head and stop lake liner flotation. Once activated, the sump pump operates on an automatic level switch.

An aquifer pumping test and associated dye-trace test that were completed in July 1998 provide the most recent data regarding the hydrologic characteristics of the intermediate and deep groundwater flowpaths in the Maynardville Limestone and the degree of hydraulic connection between the shallow and deep flow systems in the eastern plant area (SAIC 1998). A stepped pump test was performed using a well (GW-845, monitored interval = 156.8 to 438.3 ft bgs) installed in the Maynardville Limestone about 250 ft southeast of New Hope Pond. Beginning on July 9, 1998, groundwater was continuously pumped from the well at progressively increased discharge rates: 25 gallons per minute (gpm) for 24 hours, 50 gpm for 24 hours, and 100 gpm for seven days (pumping stopped on July 18, 1998). Water level drawdown and recovery data obtained from nearby monitoring wells indicated: (1) rapid, large responses in wells located along strike to

the east and across strike to the north of the pumping well, (2) more moderate responses in wells located oblique to strike near the contact with the Nolichucky Shale to the east of the pumping well, (3) weak responses in upgradient wells in the Maynardville Limestone to the west of the pumping well, and (4) little if any response in wells located adjacent to Lake Reality and the UEFPC distribution channel underdrain to the north and northeast of the pumping well. The maximum observed radius of influence from the pumping well encompassed the entire subcrop of the Maynardville Limestone in the eastern plant area, with particularly strong anisotropies to the east (along strike) and north (up-dip) of the well and low-permeability boundary effects evident along the contact with the Nolichucky Shale. Additionally, the UEFPC distribution channel underdrain, the original UEFPC mainstem, and Lake Reality apparently represent constant head (recharge) sources to the shallow groundwater and may collectively function as a hydraulic boundary to the west and northwest of New Hope Pond. The UEFPC distribution channel underdrain in particular appears to function as a separate hydraulic system that may be at least partially connected to surface water flow in UEFPC (SAIC 1998).

In conjunction with the pumping test, orange eosine dye was injected in a shallow (60 ft bgs) well (GW-153) located about 450 ft southwest (upgradient) of the pumping well (GW-845). Rapid breakthrough of the dye observed in the pumping well clearly demonstrated the hydraulic connection between the shallow and intermediate/deep groundwater flowpaths along strike in the Maynardville Limestone. Additionally, confirmed detection of the dye in two shallow wells (GW-220 and GW-832) located about 600 ft northeast (across geologic strike) of the injection well (and about 300 ft northwest of the pumping well) suggests that the degree of hydrologic connection with the UEFPC distribution channel underdrain and groundwater movement along dip parallel or conjugate fracture flowpaths in the shallow flow system are strong enough to overcome the hydraulic capture zone created at the 100 gpm pumping rate in the intermediate to deep flow systems (SAIC 1998).

## **2.4 Contaminant Source Areas**

Sources of groundwater contamination in the East Fork Regime include: hazardous and nonhazardous waste treatment, storage, or disposal sites; bulk product transfer, storage, and use areas; former petroleum-fuel underground storage tanks and associated dispensing facilities; industrial process buildings; waste and product spill areas; and the many process pipelines, effluent drains, and utilities associated with the industrial operations at the Y-12 Plant (Table B.1). Also, operation of the S-3 Ponds, a closed RCRA regulated surface impoundment located in the Bear Creek Hydrogeologic Regime near the west end of the Y-12 Plant, emplaced a large reservoir of contamination in the western plant area. It is more difficult to conclusively identify other sources of groundwater contamination elsewhere in the regime because of extensive intermingling of contaminants, but groundwater contaminant signatures (i.e., specific contaminants or distinct groups of contaminants) can be related to one or more of the source areas.

## **2.5 Extent of Groundwater Contamination**

The following overview of the extent of groundwater and surface water contamination in the East Fork Regime is based on the comprehensive description presented in the RI report. Principal groundwater contaminants in the regime are inorganic compounds (primarily nitrate); trace metals (notably uranium); volatile organic compounds (VOCs), including chlorinated solvents and petroleum hydrocarbons; and several radionuclides, chiefly technetium-99 (Tc-99) and uranium isotopes. Intermingling of contaminants from multiple source areas has produced an extensive, essentially continuous groundwater contaminant plume of varying composition that extends from the western plant area through the southern part of the central and eastern plant areas and into Union Valley east of the ORR (Figure 5).

A plume of nitrate contamination originating from the S-3 Ponds extends vertically in the aquitard at least 150 ft bgs and laterally at least 5,000 ft into the western plant area. Nitrate (as N) concentrations (hereafter

synonymous with “nitrate” concentrations) within the plume exceed 10,000 milligrams per liter (mg/L). Because it is chemically stable and highly mobile in groundwater, nitrate probably traces the overall migration pattern for other groundwater contaminants from the S-3 Ponds. The geometry of the nitrate plume indicates two principal migration pathways: (1) relatively rapid migration along fairly short, shallow pathways (<30 ft bgs) that typically terminate in storm drains or other utilities, building sumps, and the buried tributaries and original mainstem of UEFPC; and (2) much slower migration along much longer strike-parallel pathways at greater depths in the bedrock toward basement sumps in Buildings 9204-4, 9201-4, and 9201-5 (DOE 1998).

The low pH groundwater of the contaminant plume adjacent to the S-3 Ponds contains a diverse mix of metal ions and/or ion-complexes (beryllium, cadmium, cobalt, manganese, mercury, and nickel) that are usually not mobile (or are more readily attenuated) in less acidic groundwater, as well as metals that are mobile under a wider range of groundwater pH conditions (barium, boron, strontium, and uranium). Some of these metals were entrained in the acidic wastes disposed at the site (e.g., uranium), and others were dissolved from the underlying saprolite and bedrock (e.g., barium). Trace metal concentrations within the plume exceed applicable maximum contaminant levels (MCLs) for drinking water by an order of magnitude or more. Similarly elevated concentrations of several other trace metals (including boron, cadmium, cobalt, copper, mercury, and uranium) occur in the groundwater elsewhere in the East Fork Regime, notably the S-2 Site, but available data do not indicate that extensive plumes of metal ions and/or ion-complexes have developed in the groundwater beyond the immediate vicinity of these sites (Table B.1).

Volatile organic compounds are the most pervasive groundwater contaminants in the East Fork Regime. Chloroethenes, primarily tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (c12DCE), 1,1-dichloroethene (11DCE), and vinyl chloride, are the principal components of dissolved VOC plumes in the western plant area and the central plant area. Chloroethanes, primarily 1,1,1-trichloroethane (111TCA) and 1,1-dichloroethane (11DCA), are also major components of several plumes in the central plant area. Chloromethanes (carbon tetrachloride, chloroform, and methylene chloride) are primary plume components in the eastern plant area. Additionally, residual plumes of dissolved petroleum hydrocarbons (benzene, ethylbenzene, dimethylbenzene, and toluene) occur in shallow groundwater near former petroleum fuel underground storage tanks located in each plant area. Concentrations of individual plume constituents in the aquitard near the Waste Coolant Processing Area (WCPA), Building 9212, and Tank T0134-U (Figure 5) exceed 1,000 micrograms per liter (µg/L) and indicate the presence of dense, nonaqueous phase liquids (DNAPL) in the subsurface. Data for the existing network of aquifer monitoring wells generally define a relatively continuous plume of dissolved VOCs in the water table interval/shallow bedrock (<100 ft bgs) that extends eastward from the Fire Training Facility in the western plant area, intermingles with plumes from several sources in the central plant area, and extends underneath New Hope Pond in the eastern plant area (Figure 5). The extent of the plume at intermediate (>200 ft bgs) and deep (>400 ft bgs) intervals in the Maynardville Limestone is not well defined in the western and central plant areas because of limited well coverage, but data from the network of wells in the eastern plant area show that a plume of dissolved chloromethanes (primarily carbon tetrachloride), which is believed to originate from suspected DNAPL in the Maynardville Limestone west of New Hope Pond near Building 9720-6, extends vertically more than 400 ft bgs and laterally (parallel with geologic strike) into Union Valley at least 2,000 ft east of the ORR boundary (Figure 5).

Groundwater with radiological contamination occurs primarily in the aquitard east of the former S-3 Ponds, at Tank 0134-U, and Buildings 9204-4 and 9201-5, and the Salvage Yard; and in the aquifer near the S-2 Site and upgradient of New Hope Pond (the uranium oxide vault, wells GW-605 and GW-606, and the former Oil Skimmer Basin) (Table B.1 and Figure 5). The S-3 Site is the confirmed source of uranium isotopes, primarily uranium-234 (U-234) and uranium-238 (U-238), and Tc-99; the migration of Tc-99 generally

mirrors that of nitrate from the site. Limited influx of radiological contamination into the aquifer (or extensive dilution) is indicated by the greatly decreased gross alpha, gross beta, and isotopic uranium activity in the groundwater downgradient of confirmed source areas (e.g., S-2 Site and the former Oil Skimmer Basin). This pattern suggests that the alpha activity in the groundwater at aquifer wells GW-605 and GW-606 and the area upgradient of New Hope Pond reflects similarly limited migration of uranium isotopes from relatively nearby upgradient source areas.

### 3.0 CY 1999 MONITORING DATA EVALUATION

An evaluation of the monitoring data for the network of CY 1999 sampling locations in the East Fork Regime, as reported in the CY 1999 Groundwater Monitoring Report (GWMR) issued by Y-12 Plant GWPP (AJA Technical Services, Inc. [AJA] 2000a) is provided in the following sections. This evaluation mirrors the applicable requirements of DOE Order 5400.1A. Section 3.1 contains an evaluation of groundwater quality in areas that are, or could be, affected by Y-12 Plant operations (hereafter referenced as Surveillance Monitoring). Section 3.2 contains an evaluation of surface water and groundwater quality where contaminants are most likely to migrate beyond the ORR property line (hereafter referenced as Exit Pathway/Perimeter Monitoring). Long-term trends in groundwater quality at the Y-12 Plant, based on data for selected wells in the western, central, and eastern plant areas, are described in Section 3.3. Each evaluation is based on historical and CY 1999 results that meet the applicable data quality objectives (DQOs) defined in: *Y-12 Plant Groundwater Protection Program - Groundwater Monitoring Program Data Management Plan* (SAIC 2000). Detailed descriptions of the DQO criteria and associated data screening process, along with summaries of the CY 1999 data that do not meet applicable DQOs, are provided in Section 2.6 of the CY 1999 GWMR.

#### 3.1 Surveillance Monitoring

Monitoring results reported for 37 of the monitoring wells that were sampled during CY 1999 were evaluated for the purposes of Surveillance Monitoring in the East Fork Regime (Table B.2). As shown in the following summary, eight of these wells are located in the western plant area, 16 of the wells are located in the central plant area, and 13 wells are located in the eastern plant area (Figure 6).

**Table 1. Network of wells used for CY 1999 Surveillance Monitoring in the East Fork Regime**

Western Plant Area	Central Plant Area		Eastern Plant Area	
GW-108	GW-193	GW-781	GW-148	GW-605
GW-109	GW-204	GW-782	GW-153	GW-606
GW-192	GW-218	GW-783	GW-154	GW-762
GW-251	GW-219	GW-788	GW-168	GW-763
GW-253	GW-769	GW-789	GW-223	GW-832
GW-337	GW-770	GW-791	GW-380	
GW-618	GW-775	GW-792	GW-382	
GW-620	GW-776	GW-820	GW-383	

Twenty-three of these wells were sampled at least twice (semiannually) and the remaining eight wells were sampled only once during CY 1999 (Table B.2).

Along with the data for the monitoring wells listed above, the CY 1999 sampling results reported for the following building sumps were evaluated for the purposes of Surveillance Monitoring in the East Fork Regime: 9201-5N-J4, 9204-2-NE, 9204-2-NW, 9204-2E-NW, and 9204-4ELSU. One of the sumps (9204-4ELSU) is in a process building located in the western plant area and the remaining sumps are in process buildings located in the central plant area (Figure 6); each sump was sampled once during CY 1999 (Table B.2).

### 3.1.1 Western Plant Area

One or more of contaminants were detected in at least one of the groundwater samples collected during CY 1999 from each of the eight wells and the building sump used for Surveillance Monitoring purposes in the western plant area. Inorganic contaminants detected in the samples were barium, cadmium, cobalt, copper, chloride, manganese, nickel, nitrate, potassium, sodium, strontium, and uranium. Organic contaminants detected in the samples were acetone, PCE, TCE, c12DCE, trans-1,2-dichloroethene (t12DCE), 11DCE, 11DCA, 111TCA, carbon tetrachloride, chloroform, methylene chloride, dimethylbenzene, and toluene. Radiological contaminants detected in the samples were alpha radioactivity, beta radioactivity, Tc-99, and uranium isotopes (primarily U-234 and U-238). The type(s) of groundwater contaminant in each well and building sump, along with the hydrogeologic unit and monitored interval depth for each well, are shown in the following summary.

**Table 2. Types of contaminants detected in wells and building sumps used for CY 1999 Surveillance Monitoring in the western plant area**

CY 1999 Sampling Location	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-108	41.0 - 58.6	. . .	°	°	°
GW-109	96.6 - 128.5	. . .	°	°	°
GW-192	6.5 - 17.5	. . .	°	°	°
GW-251	. . .	35.0 - 51.0	°	°	°
GW-253	. . .	36.2 - 50.0	°	°	°
GW-337	15.0 - 22.1	. . .	°	°	°
GW-618	. . .	26.0 - 37.0	°	°	°
GW-620	. . .	61.7 - 75.0	°	°	°
9204-4-ELSU	. . .	. . .	°	°	°

The CY 1999 monitoring results for these wells and building sumps are generally consistent with respective historical data and reflect migration of contaminants from the S-3 Site, the Beta-4 Security Pits, the S-2 Site, the WCPA, the Salvage Yard, the Fire Training Facility, or a combination of source areas.

#### 3.1.1.1 Inorganic Contaminants

Aquitard monitoring wells GW-108 and GW-109 lie within the contaminant plume emplaced during operation of the former S-3 Ponds. These wells are part of a well cluster located about 800 ft southeast of the site (Figure 6) and monitor the long-term strike-parallel migration pathways in the Nolichucky Shale east of the site (DOE 1998). Data obtained from these wells during CY 1999 show that both yield moderately acidic (field pH 5.37 - 5.64) and highly mineralized (total dissolved solids exceed 50,000 mg/L) groundwater samples characterized by very high concentrations of calcium (10,400 - 14,500 mg/L), nitrate (9,180 - 11,800 mg/L), magnesium (1,130 - 1,290 mg/L), sodium (513 - 538 mg/L), chloride (158 - 190 mg/L), and manganese (112 - 151 mg/L). The vertical hydraulic gradient near these wells is consistently upward from intermediate depth well GW-109 toward shallow bedrock well GW-108. Additionally, the CY 1999 data show that, with the notable exception of barium and manganese, the concentrations of most trace metals remain substantially higher in well GW-109 compared to well GW-108. For example, total cadmium concentrations in the unfiltered samples collected from well GW-108 in February and July 1999 do not

exceed the associated reporting limit (0.001 mg/L), whereas a total cadmium concentration of 1.76 mg/L was reported for the unfiltered groundwater sample collected from well GW-109 in September 1999.

Comparison with historical results shows that nitrate concentrations in well GW-108 continue to decrease but appear to be decreasing at a slower rate than evident during the late 1980s (Figure 7). For instance, nitrate concentrations decreased about 30% between March 1988 (18,000 mg/L) and January 1990 (13,100 mg/L) but only about 1% between June 1995 (10,000 mg/L) and July 1999 (9,880 mg/L). Nevertheless, decreasing nitrate concentration trends are consistent with substantially reduced flux of nitrate following the closure/capping of the former S-3 Ponds, and may indicate that the center of mass of the Eastern S-3 Site Plume at shallow depths (<100 ft bgs) now lies to the east (along geologic strike) of well GW-108. Similarly, the CY 1999 results for deeper well GW-109 show that nitrate concentrations, although slightly lower than in well GW-108, remain very high (9,180 mg/L). Comparison to historic data for well GW-109 shows that nitrate concentrations have been steady to slightly decreasing, although the CY 1999 result is slightly higher than when the well was last sampled in June 1995 (8,850 mg/L).

Several inorganic contaminants, including barium, cadmium, chloride, lead, manganese, mercury, nitrate, sodium, strontium and uranium, were detected in the groundwater sample collected in February 1999 from sump 9204-4ELSU, which is used to de-water an elevator shaft located near the southeast corner of Building 9204-4 (Figure 6). Analytical results for this sample show that the concentrations of these contaminants remain well above background levels, with nitrate (1,520 mg/L) and (total) barium (6.2 mg/L) concentrations exceeding respective MCLs. The (total) uranium concentration (0.14 mg/L) was almost an order-of-magnitude greater than the 0.02 mg/L proposed federal MCL for uranium (U.S. Environmental Protection Agency 2000). The contaminant plume emplaced during operation of the former S-3 Ponds, which are about 3,000 ft west (along geologic strike) of sump 9204-4ELSU (Figure 6), is the source of many of these contaminants, particularly the “signature” contaminants from the S-3 Ponds such as nitrate and Tc-99. However, some of the other contaminants present in the sump may be from one or more local source areas. For instance, the relatively neutral pH (field pH 7.77 - 7.79) of the groundwater in sump 9204-4ELSU suggests a localized source of uranium because uranium is usually mobile only under more acidic or basic pH conditions (Fetter 1993). In any event, comparison with available historical data indicates that the concentrations of the more mobile contaminants in the sump have remained fairly unchanged since the mid-1990s, whereas the concentration of the less mobile contaminants have decreased substantially over this period. For instance, the highest nitrate (1,500 mg/L) and total barium (6.88 mg/L) concentrations evident during CY 1994 do not differ substantially from respective concentrations evident during CY 1999, whereas the total mercury concentration evident during February 1999 (0.00245 mg/L) is at least an order-of-magnitude lower than evident during CY 1994.

Aquifer monitoring well GW-251 yields contaminated calcium-magnesium-bicarbonate groundwater from a relatively shallow depth (<50 ft bgs) in the upper Maynardville Limestone about 100 ft west of the S-2 Site (Figure 6). Historical data show that nitrate and trace metals (notably cadmium) are the primary inorganic contaminants in the groundwater at the site, and the CY 1999 sampling results for well GW-251 show that nitrate levels (25.5 - 73.33 mg/L) and total cadmium concentrations (0.0498 - 0.12 mg/L) remain well above respective MCLs (10 and 0.005 mg/L). These inorganic contaminants probably leach directly from the S-2 Site into the shallow groundwater in the Maynardville Limestone and are transported via karst flow downgradient (along strike) to the east and west (DOE 1998). This also explains the clearly seasonal fluctuations in the concentration of these inorganic contaminants, with higher concentrations typically evident during seasonally high flow (Figure 8). The CY 1999 nitrate results, for example, show that the concentration in May 1999 (73.33 mg/L) is almost three times higher than the concentration in November 1999 (25.5 mg/L). Historical nitrate results for well GW-251 also reflect a generally decreasing long-term concentration trend (Figure 8).

The CY 1999 results for aquifer well GW-253 provide the most recent data regarding the concentrations of groundwater contaminants in the Maynardville Limestone along strike-parallel migration pathways in the shallow karst network immediately east of the S-2 Site (Figure 6). Groundwater samples were collected from well GW-253 in February, August, and November 1999 (Table B.2), and the analytical results for these samples show that the well continues to yield moderately acidic (field pH 4.8 - 5.3) calcium-magnesium-bicarbonate groundwater characterized by high concentrations of nitrate (788 - 952 mg/L), chloride (123 - 137 mg/L), copper (36.2 - 39.3 mg/L), cadmium (3.27 - 3.7 mg/L), manganese (49.3 - 54.3 mg/L), nickel (1.78 - 2.01), and zinc (4.94 - 6.25 mg/L). These results are consistent with historical data for the well and confirm that the highest concentrations within the contaminant plume occur to the east of the S-2 Site. Discharge from the shallow karst system into UEFPC combined with dilution during transport substantially reduces contaminant concentrations in the groundwater downgradient of the site (DOE 1998).

Aquifer well GW-618 yields moderately contaminated calcium-magnesium-bicarbonate groundwater from shallow (<50 ft bgs) flowpaths in the lower Maynardville Limestone about 750 ft northeast (downgradient) of the S-2 Site (Figure 6). Historical data show that chloride and cadmium are the principal inorganic contaminants in the groundwater at this well, and the CY 1999 results support these findings: chloride levels remain above 15 mg/L, which is about ten times higher than typical of most other shallow aquifer wells in the East Fork Regime, and total cadmium concentrations range from at (0.005 mg/L) to slightly above (0.00913 mg/L) the MCL. Considering the mobility of chloride and its chemical stability in groundwater, the chloride in the well may be from any number of upgradient source areas. The source of the cadmium in the well may be the S-2 Site, particularly in light of the very high concentration evident in well GW-253, which is only about 600 ft from GW-618 (Figure 6).

Respective total and dissolved potassium concentrations reported for the groundwater samples collected from aquifer well GW-620 in May 1999 (15 mg/L) and December 1999 (15 mg/L) are substantially higher than typical of samples from other aquifer wells in the East Fork Regime. Completed at a depth of 75 ft bgs in the upper Maynardville Limestone about 100 ft east (downgradient) of the Fire Training Facility (Figure 6), this well often yields geochemically distinctive groundwater samples characterized by unusually low calcium (<70 mg/L), low magnesium (<5 mg/L), and bicarbonate alkalinity (<1 mg/L), along with atypically high carbonate alkalinity (>20 mg/L) and pH (>10). The source of the potassium may be ash and/or inorganic flame retardants that may have been used to extinguish fires at existing and former burn areas in the western part of the Fire Training Facility, which are the likely source of dissolved VOCs in the groundwater at the well (see Section 3.1.1.2).

### **3.1.1.2 Volatile Organic Compounds**

Excluding false-positive results, one or more of the following VOCs were detected in at least one groundwater sample collected during CY 1999 from sampling locations in the western plant area: PCE, TCE, c12DCE, t12DCE, 11DCE, vinyl chloride, carbon tetrachloride, chloroform, methylene chloride, 111TCA, 11DCA, dimethylbenzene, toluene, acetone, and bromoform. Maximum summed VOC concentrations are less than 10 µg/L in building sump 9204-4ELSU; range between 10 and 100 µg/L in wells GW-192, GW-618, and GW-620; exceed 100 µg/L in wells GW-108, GW-109, and GW-251; and exceed 1000 µg/L in wells GW-253 and GW-337 (Table B.3). As shown in the following summary, the maximum concentrations of PCE, TCE, c12DCE, vinyl chloride, carbon tetrachloride, and methylene chloride exceed applicable MCLs.



**Table 3. Western plant area: CY 1999 maximum VOC concentrations that exceed MCLs**

Well or Building Sump	Maximum Concentration ( µg/L)					
	PCE	TCE	c12DCE	Vinyl Chloride	Carbon Tetrachloride	Methylene Chloride
GW-108	(1)	(3)	<5	<10	<5	<b>54</b>
GW-109	<b>170</b>	<b>6</b>	2	<10	<5	<b>15</b>
GW-192	5	7	24	<10	<5	<5
GW-251	<b>310</b>	<b>140</b>	10	<10	<b>8</b>	<5
GW-253	<b>890</b>	<b>960</b>	<b>250</b>	<b>53</b>	<b>57</b>	<5
GW-337	<b>940</b>	<b>1,000</b>	<b>5,600</b>	<b>66</b>	<5	<5
GW-618	<b>13</b>	<b>12</b>	25	<b>(3)</b>	<5	<5
GW-620	<b>25</b>	<b>11</b>	26	<10	<5	<5
MCL ( µg/L)	5	5	70	2	5	5
<b>Notes:</b> ( ) = Estimated concentration below the reporting limit Bold = Exceeds MCL						

The presence of dissolved VOCs in the groundwater at these wells reflects migration from the following source areas: the S-3 Ponds (GW-108 and GW-109), the Oil/Solvent Drum Storage Area and/or Salvage Yard Drum Deheader (GW-192), the WCPA (GW-337), the S-2 Site (GW-251 and GW-253), the Fire Training Facility (GW-620), and a combination of these and other VOC source areas in the western plant area (GW-618).

Maximum summed concentrations of VOCs detected in the groundwater samples collected from well GW-108 range from 82 µg/L in July 1999 to 117 µg/L in February 1999 (Table B.3). Chloromethanes (primarily chloroform and methylene chloride) are the principal components of the dissolved VOC plume in the groundwater at the well (note that methylene chloride concentrations remain above the MCL). Compared to other components (e.g., nitrate) of the contaminant plume emplaced during operation of the former S-3 Ponds, the relatively low VOC concentrations in the groundwater at well GW-108 probably reflect the smaller volume of organic wastes disposed at the site combined with lower relative mobility in the groundwater (DOE 1998).

The CY 1999 data indicate that summed VOC concentrations in the deeper groundwater from well GW-109 (278 µg/L) are substantially higher than evident in the shallower groundwater from well GW-108. Moreover, acetone and PCE are the dominant compounds in well GW-109 and the concentrations of chloroform and methylene chloride are much lower than evident in well GW-108. These results are consistent with historical VOC data for well GW-109 and, compared to the VOC results obtained the last time this well was sampled (June 1995), indicate little if any significant change in the concentration the principal VOCs in the plume. For instance, the PCE concentration evident in September 1999 (170 µg/L) is just slightly lower than the PCE concentration evident in June 1995 (180 µg/L). In contrast, the concentrations of the dissolved chloromethanes in the groundwater at this well reflect a clearly decreasing long-term trend (Figure 7). Concentrations of methylene chloride, for example, decreased about 75% between January 1990 (58 µg/L) and September 1999 (15 µg/L).

Several VOCs, primarily c12DCE, were detected in the groundwater samples collected from aquitard well GW-192 during CY 1999 (Table B.3), which is paired with a shallow bedrock well (GW-191; not sampled in CY 1999) in the Maryville Limestone near the east side of the Beta-4 Security Pits (Figure 6). As indicated by the preceding data summary, the maximum summed VOC concentration (38 µg/L) is relatively low, although the highest concentration of TCE (7 µg/L) remains slightly above the MCL (5 µg/L). The Oil/Solvent Drum Storage Area and/or Salvage Yard Drum Deheader is the suspected source of the dissolved chloroethenes in well GW-192 (DOE 1998). Considering the vertically upward hydraulic gradients from the

shallow bedrock (GW-191) to the water table interval (GW-192), combined with an overall lack of VOCs in the groundwater at well GW-191, the presence of dissolved chloroethenes in the shallower groundwater at well GW-192 suggests strike-parallel transport in the water table interval toward discharge areas in the upper reach of BT-1 (AJA 1996). Additionally, the preponderance of c12DCE relative to PCE and TCE suggests natural biodegradation. As shown in the following summary, several geochemical characteristics of the groundwater, particularly the oxidation-reduction potential (REDOX), are within the optimum range for anaerobic reductive dechlorination of PCE.

**Table 4. Geochemical indicators for biodegradation of chlorinated solvents in aquitard well GW-192**

<b>Geochemical Parameter/ Optimum Range (Wilson <i>et al.</i> 1996)</b>	<b>May 1998</b>	<b>November 1998</b>	<b>May/June 1999</b>	<b>November 1999</b>
Nitrate < 1 mg/L	0.072 mg/L	0.03 mg/L	<0.028 mg/L	0.0477
Iron (II) > 1 mg/L	2.62 mg/L*	4.44 mg/L*	6.61 mg/L*	5.85*
Sulfate < 20 mg/L	6.53 mg/L	3.78 mg/L	3.58	4.83
REDOX < 50 millivolts (mV)	24 mV**	-64 mV**	5**	-44**
pH 5 < pH < 9	6.44**	7.02**	6.6**	7.03**
<b>Notes:</b> *Results are for total iron; **Field measurement.				

Several factors influence this process, including the availability of electron donors (e.g., hydrogen), and the efficiency of the process differs under methanogenic, sulfate-reducing, iron-reducing, and nitrate-reducing conditions (Chapelle 1996). The apparent lack of vinyl chloride in the groundwater at well GW-192 suggests that the strongly reducing (methanogenic) conditions necessary to transform 1,2-DCE isomers to vinyl chloride either do not occur or that the vinyl chloride is oxidized to carbon dioxide (Wilson *et al.* 1996).

The CY 1999 monitoring results for aquitard well GW-337 show that some of the highest VOC concentrations (>5,000 µg/L) in the East Fork Regime occur in the aquitard near the WCPA. Based on historical data, shallow groundwater at the site contains a fairly heterogeneous mixture of chloroethenes and chloroethanes. Well GW-337, which was last sampled in May 1995, yields highly contaminated calcium-magnesium-bicarbonate groundwater from less than 25 ft bgs in the Nolichucky Shale near the southwest corner of the site (Figure 6). The high concentration of dissolved VOCs at well GW-337 is probably related to DNAPL at the WCPA, which would provide a fairly stable long-term source of VOCs to groundwater downgradient of the site (DOE 1998). Historical data for the well show a clearly decreasing long-term trend for summed chloroethene and chloroethane concentrations and that c12DCE is the dominant constituent (Figure 9). However, the September 1999 concentrations of most compounds appear to have stabilized since the well was last sampled in May 1995, which may reflect a change from the conventional sampling method to the low-flow sampling method. As shown in the following data summary (Table 5), the summed VOC concentration for the September 1999 sample is nearly the same as in the May 1995 sample.

**Table 5. Selected VOC data for aquitard well GW-337, 1991-1999**

VOC	Concentration ( µg/L)			
	Conventional Sampling Method			Low-Flow
	July 1991 (Diluted Sample)	September 1993 (Diluted Sample)	May 1995 (Diluted Sample)	September 1999
<b>Chloroethenes</b>				
PCE	930	760	790	940
TCE	1,300	1,000	870	1,000
1,2-DCE (total)	11,000	8,100	5,700	5,657
c12DCE	NR	NR	NR	5,600
t12DCE	NR	NR	NR	57
11DCE	280	210	170	130
Vinyl chloride	310	230	<250	66
<b>Chloroethanes</b>				
111TCA	430	360	290	180
11DCA	190	160	150	130
SUMMED VOCS:	14,440	10,820	8,220	8,103
<b>Note:</b> NR = Not reported				

The long-term chloroethene results for well GW-337 show that the PCE concentrations (parent compound) have remained fairly steady, while the 12DCE and vinyl chloride concentrations (degradation products) have decreased. The data for this well generally do not indicate geochemical conditions for natural biodegradation of the dissolved VOCs in the groundwater. For instance, the CY 1999 results show that total iron concentrations (<0.01 mg/L) and REDOX (149 mV) are not within the respective optimal anaerobic ranges (Wilson *et al.* 1996). Also, the historical chloroethane data generally indicate an overall decrease in the concentration of the parent compound (111TCA) and degradation products (e.g., 11DCA and 11DCE) (Figure 9). Thus, it is not clear from the available data if hydrologic (e.g., dilution and dispersion) or biological mechanisms are the primary attenuation processes working to decrease VOC concentrations in the groundwater at well GW-337.

Historical data show that aquifer well GW-251 monitors the plume of dissolved chloroethenes (primarily PCE and TCE) and chloromethanes (carbon tetrachloride and chloroform) VOCs that originates from the S-2 Site. The VOC results obtained during CY 1999 are consistent with the historical results and show: (1) higher summed concentrations of chloroethenes (460 µg/L) relative to chloromethanes (21 µg/L), (2) substantially higher maximum concentrations of PCE (310 µg/L) and TCE (140 µg/L) relative to 1,2-DCE isomers (10 µg/L), (3) large proportions (>50%) of chloroform relative to carbon tetrachloride (particularly during the dry season), (4) a higher summed VOC concentration (481 µg/L) during seasonally high groundwater flow (May 1999), and (5) relatively stable or indeterminate long-term concentration trends, with the summed VOC concentrations in December 1999 (88 µg/L) nearly equal to the summed VOC concentration evident in May 1995 (89 µg/L). Seasonally variable concentrations suggest flushing of VOCs from the shallow karst network during seasonally and/or episodically high flow conditions in the Maynardville Limestone (DOE 1998).

Aquifer well GW-253 also monitors the plume of dissolved chloroethenes and chloromethanes originating from the S-2 Site. Moreover, considering that the summed maximum concentration of the VOCs detected in well GW-253 (953 µg/L) is about double the summed maximum concentration of the VOCs detected in

well GW-251, the results for well GW-253 suggest greater strike-parallel flux of VOCs to the east rather than west of the site. The CY 1999 results for well GW-253 also show that maximum concentrations of carbon tetrachloride (57 µg/L), PCE (890 µg/L), TCE (960 µg/L), c12DCE (250 µg/L), and vinyl chloride (53 µg/L) exceed respective MCLs. Compared to the results obtained when the well was last sampled (June 1996), the CY 1999 VOC data also suggest an increasing long-term concentration trend (see Section 3.3).

Relatively low (<50 µg/L) summed concentrations of chloroethenes (PCE, TCE, c12DCE, and vinyl chloride) were detected in the groundwater samples collected from aquifer well GW-618 during CY 1999, but the maximum concentrations of PCE (13 µg/L), TCE (12 µg/L), and vinyl chloride (3 µg/L) remain above respective MCLs. This well intercepts bedrock interval migration pathways for a plume of dissolved chloroethenes (primarily PCE) originating from one or more upgradient sources in the western plant area (DOE 1998). Comparison with historical data indicates relatively steady or indeterminate long-term VOC concentration trend in well GW-618.

Historical results show that aquifer well GW-620 monitors a plume of dissolved chloroethenes, along with lesser amounts of chloroethanes and petroleum hydrocarbons, that originates from former burn areas in the western part of the Fire Training Facility (DOE 1998). Several of these compounds, such as c12DCE and vinyl chloride, are probably present as biodegradation products of parent compounds (e.g., PCE or TCE) used at the site. In any event, the summed concentrations of VOCs detected in the groundwater samples collected from the well in May 1999 (68 µg/L) and November 1999 (19 µg/L) are consistent with historical data showing a clearly decreasing long-term trend (Figure 10). This decreasing trend clearly reflects the natural (biotic and abiotic) attenuation in the Maynardville Limestone following closure of the burn areas at the Fire Training Facility.

### 3.1.1.3 Radioactivity

As noted in Section 2.5, radiological contamination in the western plant area occurs primarily in the Nolichucky Shale east of the S-3 Site and in the Maynardville Limestone near the S-2 Site. This overall distribution of radiological contamination is reflected by the gross alpha and gross beta results reported for the network of CY 1999 sampling locations in the western plant area. As shown in the following summary of CY 1999 data (Table 6), gross alpha activity above the associated minimum detectable activity (MDA), and the corresponding counting error (CE), was reported only for the groundwater samples (including duplicates) collected from aquifer wells GW-251 and GW-253, and only the gross alpha results reported for the latter well exceed the 15 picoCuries per Liter (pCi/L) MCL for drinking water.

**Table 6. Western plant area: CY 1999 gross alpha and gross beta results that exceed MDAs**

Well Number	Date Sampled	Gross Alpha (pCi/L)		Gross Beta (pCi/L)			
		MDA	Activity ± CE		MDA	Activity ± CE	
GW-108	02/15/99	174	<MDA		208	7,676	± 269
	07/27/99	174	<MDA		223	10,745	± 311
GW-109	09/02/99	320	<MDA		800	11,000	± 1,100
GW-192	11/01/99	4.8	<MDA		7.6	9.9	± 5.2
GW-251	05/27/99	4.1	9.8	± 4.6	9.1	<MDA	
GW-253	02/08/99	12.88	37.2	± 11.14	8.93	22.2	± 5.94
	08/24/99	9.39	41.9	± 9.17	8.3	18.7	± 5.43
	11/08/99	11.18	51.7	± 10.01	8.32	39.07	± 6.06
GW-618	11/09/99	2.52	<MDA		0.72	4.13	± 0.57
GW-620	05/27/99	4.1	<MDA		8.6	10	± 5.8
	11/08/99	1.7	<MDA		6.7	15	± 5
9204-4ELSU	02/17/99	34	<MDA		86	3,400	± 44

The preceding data summary also illustrates the more widespread detection of beta radioactivity in the western plant area; whereas gross alpha activity above the associated MDA was reported only for samples from wells at the S-2 Site, gross beta above the associated MDA was reported for at least one groundwater sample collected from each of the wells in the western plant area except GW-251, with very high gross beta activity evident in aquitard wells GW-108 and GW-109 building sump 9204-4ELSU.

Although historical monitoring data and operational information indicate a diverse population of alpha- and beta-emitting radioisotopes originating from the contaminant plume emplaced during operation of the former S-3 Ponds, the very high level of beta radioactivity in the groundwater samples collected from wells GW-108 ( $10,745 \pm 269$  pCi/L) and GW-109 ( $11,000 \pm 1,100$  pCi/L) is primarily from Tc-99. Although Tc-99 is volatilized during gross beta analyses (gross beta activity is typically less than the Tc-99 activity), elevated gross beta results generally correlate with elevated Tc-99 activity near the S-3 Site. Analytical results for the samples collected from well GW-108 during CY 1999 show Tc-99 concentrations ranging from  $24,151 \pm 97$  pCi/L (July 1999) to  $25,100 \pm 45$  pCi/L (February 1999), which are the highest Tc-99 levels ever reported for the well and reflect a clearly increasing long-term trend (see Section 3.3). Under oxidizing conditions, Tc-99 occurs as the pertechnetate anion ( $\text{TcO}_4^-$ ) which is soluble and highly mobile in groundwater (Gee *et al.* 1983). Thus, temporal changes in Tc-99 concentrations potentially reflect temporal changes in the total flux of Tc-99. This is of particular interest considering the diverging long-term gross beta concentration trends in these wells (Table B.4). A clearly increasing gross beta trend is evident in the shallow groundwater at well GW-108 (see Section 3.4) whereas a clearly decreasing gross beta trend is evident in the deeper groundwater at well GW-109 (Figure 7). As noted in Section 3.1.1, the vertical hydraulic gradient at these wells is upward, suggesting upward transport of contaminants. The significance of these diverging gross beta trends is not clear from the available data, but may reflect differences in the relative flux of Tc-99 in Nolichucky Shale east of the former S-3 Ponds (see Section 3.3) (AJA 2000b).

Uranium isotopes are the source of the alpha and beta radioactivity in the groundwater near the S-2 Site (DOE 1998). The CY 1999 results indicate higher levels of gross alpha and gross beta radioactivity in well GW-253 relative to well GW-251; as with other contaminants in the groundwater at this site, this probably reflects greater flux of uranium isotopes to the east of the site. Aside from this relationship, however, the gross alpha and gross beta results for these wells indicate relatively stable or indeterminate long-term trends.

As shown in the preceding summary of CY 1999 (Table 6), high gross beta activity is evident in the groundwater sample collected in February 1999 from the sump in the Building 9204-4 elevator shaft (sump 9204-4ELSU). Analytical results for this sample show that the beta activity is primarily from Tc-99 ( $6000 \pm 44$  pCi/L). These gross beta and Tc-99 results are consistent with the most recent historical data for the sump (March 1997), which show similar gross beta ( $2250 \pm 40$  pCi/L) and Tc-99 concentrations ( $5980 \pm 420$  pCi/L), and reflect a fairly stable long-term concentration trend. However, compared to this historical (March 1997) data, which show elevated gross alpha activity ( $129 \pm 18.9$  pCi/L) with U-234 ( $41 \pm 4.7$  pCi/L) and U-238 ( $204 \pm 16$  pCi/L) being the primary alpha-emitting isotopes, the February 1999 sampling results show substantially decreased levels of alpha radioactivity and uranium isotopes in this building sump. These divergent trends, as discussed in Section 3.1.1.1, at least partially reflect the relative mobility of the S-3 Ponds contaminants, whereby the concentrations of the more mobile contaminants in the sump (such as Tc-99) have increased or remained fairly unchanged since the mid-1990s, and the concentration of the less mobile contaminants in the sump (such as  $^{238}\text{U}$ ) have decreased substantially over this period.

### 3.1.2 Central Plant Area

One or more inorganic, organic, and radiological contaminants were detected in at least one of the groundwater samples collected from 14 of the wells and four of the building sumps used for Surveillance Monitoring purposes in the central plant area during CY 1999. Inorganic contaminants detected in the samples were boron, copper, chloride, chromium, lead, molybdenum, nickel, nitrate, selenium, sodium, strontium, sulfate, and uranium. Organic contaminants detected in the samples were PCE, TCE, c12DCE,

t12DCE, 11DCE, vinyl chloride, carbon tetrachloride, chloroform, methylene chloride, 111TCA, 11DCA, chloroethane, benzene, dimethylbenzene, ethylbenzene, and toluene. Radiological contaminants detected in the samples were alpha radioactivity, beta radioactivity, Tc-99, and uranium isotopes. The type(s) of groundwater contaminant in each well and building sump, along with the hydrogeologic unit and monitored interval depth for each well, are shown in the following summary (Table 7).

**Table 7. Types of contaminants detected in wells and building sumps used for CY 1999 Surveillance Monitoring in the central plant area**

CY 1999 Sampling Location	Hydrogeologic Unit/ Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-193	.	5.5 - 18.4	°	°	.
GW-204	6.5 - 17.3	.	°	°	.
GW-218	.	14.4 - 27.5	°	.	.
GW-219	.	4.3 - 11.3	°	.	.
GW-769	48.2 - 60.3	.	.	°	.
GW-770	7.5 - 19.0	.	.	°	.
GW-775	45.0 - 56.4	.	°	°	.
GW-776	10.6 - 23.0	.	°	.	.
GW-781	56.0 - 69.3	.	°	°	.
GW-782	23.8 - 35.9	.	°	°	.
GW-783	3.6 - 16.3	.	°	°	.
GW-791	57.5 - 70.6	.	.	°	.
GW-792	17.0 - 29.0	.	°	°	.
GW-820	.	? - 17.3	°	°	.
9201-5N-J4	.	.	°	°	.
9204-2-NE	.	.	°	°	.
9204-2-NW	.	.	°	.	.
9204-2E-NW	.	.	°	°	.

The extent of groundwater contamination in the central plant area reflects intermixing of contaminants from multiple sources (including DNAPL in the subsurface at several sites), and the substantial hydrologic influence exerted by the extensive areas of anthropogenic fill, subsurface drains and utilities, surface drainage conveyances, and operation of basement sumps in several of the process buildings within the Y-12 Plant (DOE 1998).

### 3.1.2.1 Inorganic Contaminants

As shown in the preceding summary, one or more inorganic contaminants were detected in all but three of the monitoring wells and each of the building sumps used for Surveillance Monitoring in the central plant area during CY 1999. Chloride, chromium, nickel, sulfate and uranium were the most frequently detected inorganic contaminants. Chloride and sulfate are probably from numerous non-specific sources, such as leaking industrial process lines, sanitary sewers, or storm drains (including chlorinated once-through cooling water). Conversely, the elevated chromium and nickel concentrations, particularly those reported for the samples collected from wells GW-776 and GW-783, potentially reflect corrosion of the stainless steel well casing and screen rather than migration from potential areas. Aside from non-specific sources of inorganic contaminants and potential corrosion artifacts, the CY 1999 monitoring results suggest that the Uranium Oxide Vault is a source of elevated uranium levels in the shallow groundwater at aquifer wells GW-218 and GW-219, and Building 9204-2 may be the source of the elevated uranium concentrations in the shallow groundwater at well GW-204.

Elevated chloride and/or sulfate concentrations were reported for the groundwater samples collected during CY 1999 from monitoring wells GW-193, GW-204, GW-218, GW-775, GW-792 and GW-820 and building sumps 9201-5N-J4, 9204-2-NE, 9204-2-NW, and 9204-2E-NW. Chloride concentrations were highest (>30 mg/L) in aquitard wells GW-775 and GW-792 and in building sumps 9201-5N-J4 and 9204-2-NW. However, because inorganic chloride accumulates during reductive dechlorination of PCE, which is a primary component of the dissolved VOC plumes in the central plant area, the elevated chloride concentrations in some of these wells and building sumps may be at least partially attributable to natural biodegradation.

Maximum total nickel concentration reported for the unfiltered groundwater samples collected during CY 1999 from wells GW-776 (0.814 mg/L), GW-783 (0.698 mg/L), and GW-792 (0.147 mg/L) exceed the drinking water MCL (0.1 mg/L). Elevated maximum total chromium concentrations also were detected in the groundwater samples from wells GW-776 (0.0694 mg/L) and GW-783 (0.598 mg/L). Because each of these wells yield groundwater with fairly neutral pH and none of the wells are located near suspected sources of nickel or chromium contamination, elevated concentrations of these metals have been interpreted to potentially reflect corrosion of the stainless steel well casing and screen (HSW Environmental Consultants, Inc. 1994; AJA 1998). These interpretations also recognized that the geochemical conditions known to be corrosive to stainless steel (e.g., dissolved oxygen >2 mg/L; Driscoll 1986) are not evident in all of the wells with elevated nickel and/or chromium concentrations. Instead of chemical corrosion, however, microbiologically induced corrosion (MIC) of stainless steel, which may be caused by many different species of bacteria (including iron-related and sulfate-reducing organisms), may explain the elevated chromium and/or nickel concentrations in these wells (AJA 1999).

To evaluate the potential for MIC of the stainless steel monitoring well casing and screen, the Y-12 Plant GWPP initiated preliminary microbiologic sampling during CY 2000 to determine what types of bacteria (if any) were present in the groundwater in selected wells, including well GW-783. These microbiologic sampling results, reported in colony forming units per milliliter (CFU/ml), indicate that the groundwater at well GW-783 contains a complex bacterial consortium that includes iron-related (5000 CFU/ml), slime-forming (1000 CFU/ml), and sulfate-reducing (100 CFU/ml) organisms (Jones 2000a). Because these types of bacteria may cause MIC of stainless steel, the elevated concentrations of nickel and chromium in the groundwater samples from this well may reflect corrosion artifacts.

Aquitard well GW-204 is a shallow well (17.5 ft bgs) that was installed into the pit from which Tank 0134-U was removed in August 1988 (HSW Environmental Consultants, Inc. 1993). Historical results for this well, which was last sampled in November 1993, show that it yields sulfate-enriched calcium magnesium bicarbonate groundwater with decreasing concentrations of dissolved petroleum hydrocarbons (see Section 3.1.2.2). Additionally, uranium concentrations reported for all but one of the 14 unfiltered groundwater samples collected from the well between June 1990 and November 1993 exceed the proposed MCL for uranium (0.02 mg/L). Analytical results for the sample collected from the well in September 1999 show that, in addition to unusually high sulfate (189.5 mg/L), the total uranium concentration (0.143 mg/L) remains above the proposed MCL (0.02 mg/L) and reflects a generally increasing long-term concentration trend (see Section 3.3) that coincides with an overall increase in alpha radioactivity in the well (see Section 3.1.2.3).

Aquifer well GW-219 is completed at a depth of about 11 ft bgs in the Maynardville Limestone about 50 ft northeast of the Uranium Oxide Vault (Figure 6). Filtered and unfiltered groundwater samples were collected from the well in December 1999 (seasonally high flow), and the analytical results for these samples indicate that this well yields calcium-magnesium-bicarbonate groundwater with high total (0.599 mg/L) and dissolved (0.614 mg/L) concentrations of uranium. These results are consistent with previous data and show that total and dissolved uranium concentrations in the shallow groundwater at well GW-219 remain at least an order-of-magnitude above the proposed MCL for uranium (0.02 mg/L). However, these very high total and dissolved uranium levels contrast with the substantially lower uranium concentration evident in aquifer well GW-218, which is completed at a depth of about 28 ft bgs in the Maynardville Limestone less than

100 ft east of the Uranium Oxide Vault (Figure 6). A groundwater sample was collected from well GW-218 in December 1999, and results indicate that this well yields calcium-magnesium-bicarbonate groundwater with total (and dissolved) uranium concentrations near 0.004 mg/L, which is substantially below the proposed uranium MCL and more than two orders-of-magnitude lower than the uranium concentrations evident in well GW-219.

### 3.1.2.2 Volatile Organic Compounds

Excluding false-positive results, at least one VOC was detected in at least one groundwater sample collected from 10 of the 16 monitoring wells and three of the four building sumps used for Surveillance Monitoring in the central plant area during CY 1999. Maximum summed VOC concentrations are less than 10 µg/L in wells GW-770, GW-775, GW-776, GW-781, GW-789, and GW-792; range between 10 and 100 µg/L in wells GW-193, GW-204, and GW-769 and building sumps 9204-2E-NW and 9204-2-NE; exceed 100 in wells GW-782 and GW-791 and building sump 9201-5N-J4; and exceed 2000 µg/L in well GW-820 (Table B.3). As shown in Table 8, the maximum concentrations of PCE, TCE, c12DCE, 11DCE, vinyl chloride, carbon tetrachloride, and benzene exceed respective MCLs for drinking water.

**Table 8. Central plant area: CY 1999 maximum VOC concentrations that exceed MCLs**

Monitoring Well or Building Sump	Maximum Concentration ( µg/L)						
	PCE	TCE	c12DCE	11DCE	Vinyl Chloride	Carbon Tetrachloride	Benzene
GW-193	.	.	.	.	.	.	<b>76</b>
GW-204	<b>16</b>	(2)	.	.	.	.	.
GW-769	<b>5</b>	.	.	.	.	<b>9</b>	.
GW-781	<b>7</b>	.	.	.	.	.	.
GW-782	<b>180</b>	<b>62</b>	15	<b>43</b>	<b>(3)</b>	.	(2)
GW-783	<b>36</b>	<b>15</b>	17	.	.	(2)	.
GW-791	<b>220</b>	(2)	.	.	.	.	.
GW-792	<b>7</b>	.	.	.	.	.	.
GW-820	<b>1,500</b>	<b>250</b>	<b>940</b>	(4)	<b>130</b>	.	.
9201-5N-J4	<b>180</b>	<b>16</b>	36	.	.	.	.
9204-2-NE	<b>52</b>	(3)	6	6	.	.	.
9204-2E-NW	<b>17</b>	.	(4)	.	.	.	.
MCL ( µg/L)	5	5	70	7	2	5	5
<b>Notes:</b> “.” = Not detected ( ) = Estimated concentration below the reporting limit Bold = Exceeds MCL							

Suspected sources of the VOCs detected in the network of wells and building sumps sampled during CY 1999 include Buildings 9204-4, 9201-4, and 9201-5; the Building 9212 vicinity (GW-791 and GW-792); several potential sites in the vicinity of Buildings 9204-2 and 9731 (GW-204, GW-781, GW-782, and GW-783); Building 9201-2 (GW-820), and Tank 2331-U (GW-193) (Figure 5).

The production complex in the vicinity of Building 9212 is the suspected source of the dissolved PCE plume in the groundwater at aquitard wells GW-791 and GW-792 (Figure 6). Historical data for these wells show maximum PCE concentrations above 1000 µg/L in the groundwater at shallow bedrock well GW-791 (71 ft bgs), which may indicate the presence of DNAPL (DOE 1998), but considerably lower PCE levels (typically below 25 µg/L) in the shallower groundwater at water table well GW-792 (29 ft bgs). Additionally, results



for both wells reflect an overall lack of PCE degradation products, indicating little if any natural biodegradation of the PCE. Minimal biodegradation of the PCE is supported by recent microbiologic sampling results for well GW-791; duplicate samples collected from the well in May 2000 contained relatively low counts (<100 CFU/ml) of slime forming bacteria (Jones 2000a). Also, the upward hydraulic gradients indicated by presampling groundwater elevations in these wells (Figure 11) indicate that dissolved PCE migrates upward from the shallow bedrock (GW-791) into the water table interval (GW-792). A fairly sudden increase in the static water level at these wells (Figure 11) probably reflects a significant leak that occurred in CY 1996 from a cooling tower located in the northeast corner of the 9212 complex (Jones 2000b). As shown in the following summary of PCE data (Table 9), the CY 1999 results are consistent with respective historical results for each well.

**Table 9. Selected PCE results for aquitard wells GW-791 and GW-792, 1996-1999**

Monitoring Well	PCE ( µg/L)							
	Conventional Sampling				Low-Flow Sampling			
	May 1996	Nov. 1996	April 1997	Nov. 1997	May 1998	Nov. 1998	May 1999	Nov. 1999
GW-791	1400	410	2100	710	330	70	220	73
GW-792	5	11	8	9	6	5	7	5

The CY 1999 PCE results for each well also confirm respective CY 1998 data indicating a substantial disparity between the conventional and low-flow sampling results for well GW-791, but little if any difference between the conventional sampling and low-flow sampling results for well GW-792. Additionally, both the conventional and low-flow sampling results for well GW-792 reflect an indeterminate long-term concentration trend that exhibits little if any seasonal concentration fluctuations. Conversely, the conventional and low-flow sampling results for well GW-791 reflect a clearly decreasing long-term PCE concentration trend and strongly seasonal concentration fluctuations (Figure 11), with concentrations during the seasonally high flow (winter and spring) three to four times higher than concentrations evident during seasonally low flow (summer and fall).

Historical data show that the concentration of dissolved petroleum hydrocarbons in the shallow groundwater at aquitard well GW-204 sharply decreased from more than 5,000 µg/L in September 1990 to less than respective analytical detection limits in December 1991. Analytical results for the groundwater sample collected from the well in September 1999 are generally consistent with these historical findings, in that petroleum hydrocarbons were not detected, but PCE and TCE were detected in this sample (the PCE concentration exceeds the MCL). Neither of these chloroethenes were previously detected in the well. The source of these chloroethenes has not been determined, but the shallow depth of the well and the proximity of the well to Building 9204-2 indicate that this building is the most likely local source (DOE 1998).

Aquitard wells GW-781, GW-782, and GW-783 comprise a well cluster in the upper Nolichucky Shale at depths of about 63 ft, 36 ft, and 16 ft bgs, respectively, about 100 ft southwest of Building 9731 (Figure 6). Historical data show that these wells yield calcium-magnesium-bicarbonate (GW-782 and GW-783) or sodium-bicarbonate groundwater (GW-781), and the groundwater in each well contains a mixed plume of dissolved chloroethenes, chloroethanes, and chloromethanes. This plume of dissolved VOCs is believed to originate from one or more sources in the vicinity of Building 9204-2 and Building 9731 (DOE 1998). The CY 1999 VOC results for these wells, summarized below, are consistent with respective historical data showing substantially higher summed VOC concentrations in well GW-782 compared to deeper well GW-781 and shallower well GW-783.

**Table 10. CY 1999 VOC results for aquitard wells GW-781, GW-782, and GW-783**

VOC and Associated Reporting Limit ( µg/L)	Concentration ( µg/L)					
	May 1999			October 1999		
	GW-781	GW-782	GW-783	GW-781	GW-782	GW-783
PCE 5	7	180	10	5	170	36
TCE 5	.	62	5	.	46	15
c12DCE 5	.	15	6	.	12	17
t12DCE 5	.	5	(3)	.	.	7
Vinyl chloride 10	.	(2)	.	.	(3)	.
111TCA 5	.	5	.	.	15	.
11DCA 5	.	110	(3)	.	160	11
11DCE 5	.	32	.	.	43	.
Chloroethane 10	.	(2)	.	.	(8)	.
Carbon Tetrachloride 5	.	.	(2)	.	.	.
Benzene 5	.	(2)	.	.	.	.
SUMMED VOCs:	7	415	29	5	457	86
<b>Notes:</b> “.” = Not detected; ( ) = Estimated concentration below the reporting limit						

Substantially higher VOC concentrations in well GW-782 compared with wells GW-781 and GW-783 suggest somewhat stratabound transport pathways. The dominantly upward hydraulic gradients indicated by presampling groundwater elevations in these wells also suggest vertically upward migration patterns. Moreover, these CY 1999 results continue the increasing long-term concentration trends evident for several of the VOCs in the well GW-782 (see Section 3.3) along with the indeterminate long-term trends evident for the VOCs detected in wells GW-781 and GW-783 (Table B.4). Long-term concentration trends for these wells also may reflect the varying influence of natural attenuation processes. For instance, biotic and/or abiotic degradation of 111TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), might at least partially account for the preponderance of 11DCA and 11DCE in well GW-782. Similarly, the results for these wells may reflect the relative degree of biodegradation as a function of the principal types of microorganisms in the groundwater at each well. This is potentially indicated by the preliminary microbiological sampling results summarized below (Table 11), which suggest that iron-related bacteria are the primary microorganisms in the shallow groundwater at well GW-783, whereas sulfate-reducing bacteria are the primary microorganisms in the deeper groundwater at well GW-782.

**Table 11. Preliminary microbiological sampling results for aquitard wells GW-782 and GW-783**

Well Number	Date Sampled	Bacteria counts (CFU/mL)		
		Iron-Related Bacteria	Sulfate-Reducing Bacteria	Slime-Forming Bacteria
GW-782	05/01/00	100	1000	<100
	05/01/00 D	100	<100	<100
GW-783	05/01/00	5000	100	1000
	05/01/00 D	5000	<100	<100
<b>Note:</b> D = Duplicate sample				

Aquitard well GW-769 is completed at depth of 60 ft bgs in the Nolichucky Shale about 200 ft northeast of Building 9201-2 (Figure 6). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater containing several dissolved chloroethenes (PCE, TCE, and c12DCE) and/or chloromethanes (carbon tetrachloride and chloroform). Because basement sumps in Building 9201-2 strongly influence local groundwater flow and contaminant transport patterns, the source(s) of these VOCs may be located to the north of the well, possibly Buildings 9202, 9203, and 9205 where large amounts of carbon tetrachloride were used to convert uranium trioxide to uranium tetrachloride (DOE 1998). The CY 1999 VOC results for well GW-769 are consistent with historical data, with relatively low concentrations (<10 mg/L) of carbon tetrachloride and PCE detected in each of the groundwater samples collected from the well; note that the carbon tetrachloride concentrations exceed the MCL. Additionally, these results continue the relatively stable or indeterminate long-term concentrations trends indicated by historical data for each well (Table B.4).

Aquitard wells GW-775 and GW-776 comprise a well cluster located near the Nolichucky Shale/Maynardville Limestone contact about 1500 ft east of aquitard well GW-769 (Figure 6). Historical data show that these wells yield calcium-magnesium-bicarbonate groundwater containing atypically high levels of chloride and sulfate along with low levels (<10 µg/L) of chloroethenes (primarily TCE) and chloromethanes (primarily chloroform). Very low concentrations of TCE (3 - 5 µg/L) were detected in each of the groundwater samples from these wells during CY 1999. These results are consistent with respective historical data showing fairly stable long-term concentrations of TCE in the groundwater at both wells. Also, the presence of TCE in the well may at least partially reflect transport facilitated by subsurface utilities because, as noted in Section 3.1.2.1, the elevated chloride and sulfate concentrations in the groundwater at these wells possibly originate from leaking sewer lines and/or storm drains. In any case, the CY 1999 results for wells GW-775 and GW-776 reflect the indeterminate long-term concentrations trends indicated by respective historical data for each well (Table B.4).

Aquifer well GW-193 is located near the eastern end of Building 9201-1 in the south-central part of the central plant area (Figure 6). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater containing a residual plume of dissolved petroleum hydrocarbons (benzene, chlorobenzene, dimethylbenzene, ethylbenzene, and toluene) originating from a petroleum fuel underground storage tank (Tank 2331-U) that was excavated and removed in December 1988 (DOE 1998). Benzene and dimethylbenzene were detected in each of the samples collected from the well during CY 1999, and the summed concentration of these petroleum hydrocarbons in February 1999 (82 µg/L) and July 1999 (50 µg/L) are consistent with historical data showing a clearly decreasing long-term concentration trend. For example, benzene concentrations reported for well GW-193 ranged from about 1,200 to 6,200 µg/L from 1991 to 1993, then decreased to about 100 to 300 µg/L from 1996 to 1998, and remain substantially above the 5 µg/L MCL for drinking water in the CY 1999 samples (48 - 76 µg/L).

Aquifer well GW-820 is located near the southwest (upgradient) corner of Building 9201-2 (Figure 6). Although construction details for this well are incomplete, available data indicate that the well is completed at a shallow depth (<25 ft bgs) in the Maynardville Limestone. This well has been sampled on three occasions; once in March 1997 to obtain data for the RI, and again in March 1998 and September 1999 by the Y-12 Plant GWPP. The VOC results for these samples, summarized below, show that well GW-820 clearly monitors a plume of dissolved chloroethenes, although there are significant differences between the concentrations of PCE and c12DCE obtained during the RI and GWPP sampling events.

**Table 12. Selected VOC results for aquifer well GW-820, 1997-1999**

Chloroethene	Concentration ( µg/L)		
	RI Sampling (Conventional)	GWPP Sampling (Low-flow)	
	March 1997	March 1998	September 1999
PCE	5	7300	1500
TCE	600	590	250
c12DCE	5000	870	940
t12DCE	NR	6	16
Vinyl Chloride	NR	65	130
SUMMED VOCs:	5605	8831	2836
<b>Note:</b> NR = Not reported			

The reason for the disparity between the PCE and 1,2-DCE results for well GW-820 may reflect the change from the conventional to the low-flow sampling method. However, the March 1998 and September 1999 results for PCE, which equal or exceed 1% of pure-phase solubility of PCE (1500 µg/L), confirm that DNAPL is probably present in the subsurface near the western (upgradient) end of Building 9201-2. These results also suggest either a strongly decreasing concentration trend or wide seasonal variations in the concentration of the dissolved VOCs in the well. Additionally, natural biodegradation of PCE in the groundwater is suggested by the (apparently) increasing concentrations of c12DCE and vinyl chloride, the latter of which substantially exceeds the MCL for drinking water (2 µg/L). In either case, the operation of de-watering sumps in the basement of Building 9201-2 probably captures the bulk of the contaminant mass in the shallow flow system near this well (DOE 1998).

### 3.1.2.3 Radioactivity

Historical monitoring data do not indicate widespread radiological contamination in the central plant area. The CY 1999 monitoring results are consistent with these historical findings; only gross alpha and gross beta results reported for the groundwater samples collected from seven of the wells and two of the building sumps used for Surveillance Monitoring exceed the corresponding MDA for each result. Additionally, most of the CY 1999 gross alpha and gross beta results that exceed the corresponding MDA (Table 13) just slightly exceed the applicable MDA and have high proportional counting errors (i.e., a high degree of analytical uncertainty).

**Table 13. Central plant area: CY 1999 gross alpha and gross beta results that exceed MDAs**

Well Number	Date Sampled	Gross Alpha (pCi/L)			Gross Beta (pCi/L)		
		MDA	Activity ± CE		MDA	Activity ± CE	
GW-193	02/16/99	2.4	<b>77.6</b>	± 5.7	2.38	29.69	± 2.18
	07/20/99	2.66	8.6	± 2.6	2.31	8.68	± 1.66
GW-204	09/13/99	5.5	<b>95</b>	± 14	7.7	30	± 6.9
GW-218	12/06/99	2.2	3.4	± 2.2	5.3	8	± 3.7
GW-219	12/02/99	2.5	<b>180</b>	± 2.5	6.4	<b>140</b>	± 10
GW-775	10/27/99	3.1	6.4	± 3.4	8.8	<MDA	
GW-782	05/24/99	4.7	<b>59</b>	± 10	9.5	16	± 6.6
	10/25/99	4	<b>43</b>	± 8.9	9.2	11	± 6.2
GW-789	10/25/99	5.8	<b>20</b>	± 6.4	9.4	<MDA	
9204-2-NW	02/16/99	6.9	<MDA		8.1	9.6	± 5.4
9204-2E-NW	02/23/99	4	14	± 5.2	8.3	47	± 8
<b>Note:</b> Bold = Activity exceeds MCL							

Results for each of these wells except GW-193 are generally consistent with respective historical data and reflect migration of radiological contaminants from several sources in the central plant area. Well GW-193 does not have a prior history of elevated gross alpha or gross beta activity, and the results reported for the sample collected from the well in February 1999 were therefore considered analytical artifacts (note the much lower gross alpha and gross beta reported for the sample collected from the well in July 1999).

Data obtained during CY 1999 support previous findings of elevated gross alpha activity in the groundwater at aquitard well GW-204. The sample collected from the well in September 1999 was not analyzed for specific isotopes, but historical results show that uranium isotopes (primarily U-234 and U-238) are the primary source of the alpha and beta radioactivity in the shallow groundwater at this well and Building 9204-4 is the presumed source of the uranium (DOE 1998). Additionally, the September 1999 gross alpha result (95 ± 14 pCi/L) is the second highest gross alpha value ever reported for the well and continues a moderately increasing long-term trend indicated by the historical data for well GW-204 (see Section 3.3).

The CY 1999 results showing elevated gross alpha activity in the groundwater at aquitard well GW-782 are consistent with historical data, including data obtained during the RI identifying U-234 as the principal alpha-emitting isotope in the well (DOE 1998). In contrast, the CY 1999 and historical data (including RI results) show essentially background levels (i.e., <MDA) of gross alpha activity in the shallower (GW-783) and deeper (GW-781) wells clustered with GW-782. Background gross alpha levels in the shallower and deeper groundwater suggest stratabound (strike- or dip-parallel) migration of uranium isotopes and associated daughter products along the groundwater flowpaths intercepted by well GW-782. Additionally, historical results for well GW-782 show a frequently inverse relationship between gross alpha activity and the presampling groundwater elevation in the well, including a notably sharp activity decrease and water level increase following a 1.8-inch rainfall in March 1995 (AJA 1996). Moreover, the CY 1999 gross alpha results for well GW-782 continue the increasing long-term concentration trend evident since the early 1990s (see Section 3.3). The source of the uranium is believed to be historical spills and leaks from nearby process buildings where large amounts of radionuclides were routinely handled (DOE 1998).

As shown in the preceding summary of CY 1999 data, the highest levels of gross alpha and gross beta activity in the central plant area were reported for the groundwater sample collected from well GW-219 in December 1999. Analytical results for this sample indicate that the alpha and beta radioactivity is primarily

from U-234 ( $31 \pm 4.8$  pCi/L) and U-238 ( $220 \pm 29$  pCi/L). The presence of uranium isotopes in the shallow groundwater at well GW-219 suggests a relatively nearby source (possibly the Uranium Oxide Vault) because these isotopes probably occur as uranyl cations, which are prone to pH-sensitive sorption reactions and consequently are not usually highly mobile in groundwater (Fetter 1993). A low level of Tc-99 ( $22 \pm 7.7$  pCi/L; MDA = 12 pCi/L) also was detected in the groundwater sample collected from the well in December 1999. The presence of Tc-99 in the shallow groundwater at this well would reflect migration from the plume of contamination emplaced in the western plant area during operation of the former S-3 Ponds (the only source area for Tc-99 at the Y-12 Plant). However, considering the distance to well GW-219 from the western plant area ( $>5,000$  ft), the shallow depth of the well (11 ft bgs), and proximity of the well to UEFPC, the presence of Tc-99 may reflect some localized inflow of contaminated surface water rather than extensive subsurface migration from the S-3 Site in the groundwater.

### 3.1.3 Eastern Plant Area

One or more inorganic, organic, and radiological contaminants were detected in at least one of the groundwater samples collected from all but one of the wells (GW-168) used for Surveillance Monitoring purposes in the eastern plant area during CY 1999. Inorganic contaminants detected in the samples were boron, chloride, chromium, iron, manganese, nickel, nitrate, sodium, sulfate, and uranium. Organic contaminants detected in the samples were PCE, TCE, c12DCE, t12DCE, 11DCE, vinyl chloride, carbon tetrachloride, chloroform, methylene chloride, 111TCA, 11DCA, chloroethane, benzene, dimethylbenzene, ethylbenzene, and toluene. Radiological contaminants detected in the samples were alpha radioactivity, beta radioactivity, and uranium isotopes. The type(s) of groundwater contaminant in each well, along with the hydrogeologic unit and monitored interval depth for each well, are shown in Table 14.

**Table 14. Types of contaminants detected in wells used for CY 1999 Surveillance Monitoring in the eastern plant area**

Well Number	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-148	4.6 - 11.1	. . .	.	°	.
GW-153	. . .	45.0 - 60.0	.	°	.
GW-154	. . .	4.7 - 11.2	.	.	°
GW-168	. . .	104.0 - 119.7	.	°	°
GW-223	. . .	79.0 . 90.5	°	°	.
GW-380	. . .	2.8 - 15.5	°	.	.
GW-382	. . .	125.0 - 173.0	°	°	.
GW-383	16.6 - 23.6	. - .	°	°	°
GW-605	. . .	28.2 . 39.9	°	°	.
GW-606	. . .	155.0 - 171.0	.	°	.
GW-762	46.4 - 58.7	. - .	.	°	.
GW-763	4.0 - 16.0	. . .	.	°	.
GW-832	4.0 - 11.8	. . .	.	°	.

Results for these wells are generally consistent with respective historical data and reflect transport of contaminants from upgradient sources within the Y-12 Plant.

### 3.1.3.1 Inorganic Contaminants

As shown in the preceding data summary, one or more inorganic contaminants were detected in eight of the wells used for Surveillance Monitoring in the eastern plant area during CY 1999. The most frequently detected inorganic compounds were chloride, nitrate, sulfate, sodium, and uranium. Atypically high concentrations of chloride, sodium, and sulfate probably reflect transport in groundwater and surface water from multiple sources (e.g., leaking process lines or subsurface drains) in the Y-12 Plant upgradient of New Hope Pond/Lake Reality. Additionally, elevated chloride concentrations may be at least partially attributable to in-situ degradation of dissolved chlorinated solvents in the groundwater (see Section 3.1.3.2) rather than migration from one or more upgradient sources of chloride.

Aquifer wells GW-605 and GW-606 comprise a well cluster completed at respective depths of 40 ft and 171 ft bgs in the lower Maynardville Limestone about 1200 ft west (hydraulically upgradient) of New Hope Pond (Figure 6). Historical data for well GW-605 show elevated total (and dissolved) concentrations of elemental uranium (and uranium isotopes). The specific source of the elemental and/or isotopic uranium has not been identified, but the well may penetrate fill material containing low-level radioactive materials potentially derived from historical uranium enrichment activities performed in Buildings 9201-1, 9201-2, and 9201-3 (DOE 1998). However, uranium was not detected in the groundwater sample collected in February 1999 and the total uranium concentration reported for the sample collected in July 1999 (0.0872 mg/L) reflects a slight increase from the uranium concentration in July 1998 (0.0464 mg/L), which was about an order-of-magnitude lower than the uranium concentration evident in March 1998 (0.33 mg/L). The sharp decrease and subsequent recovery of the uranium concentrations in the well potentially reflects the influence of the stepped pumping test described in Section 2.3. Manual water level monitoring in well GW-605 during the pumping test showed only a slight water level decrease (0.11 ft) at the end of the 7-day 100 gpm pumping interval, which may indicate constant head recharge from UEFPC (SAIC 1998). If so, increased recharge from UEFPC in response to the pumping test may have diluted the uranium concentration in the shallow flow system near the well, with the July 1999 uranium result reflecting a partial rebound toward the uranium concentrations evident in the well before the pumping test.

Although significantly below the MCL (10 mg/L), nitrate concentrations reported for the groundwater samples (including duplicates) collected from aquifer well GW-606 in February 1999 (5.1 mg/L) and July 1999 (4.6 mg/L) exceed background levels (<1 mg/L). These nitrate results support the similarly elevated nitrate concentrations reported for the samples collected from this well in March 1998 (4.8 mg/L) and July 1998 (4.69 mg/L). Additionally, the nitrate results obtained during CYs 1998 and 1999 are more than double the previous maximum nitrate concentration (1.7 mg/L in March 1995). This disparity with historical nitrate data coincides with the change from conventional sampling to low-flow sampling, which suggests that the conventional sampling method may have induced flow of uncontaminated groundwater into the well. Nitrate in the groundwater at well GW-606 potentially indicates substantial (>5000 ft) strike-parallel migration from the contaminant plume(s) emplaced during operation of the S-2 Site or the former S-3 Ponds (Figure 6). Alternatively, nitrate concentrations in the groundwater at this well may reflect migration from a former stockpile of urea used to remove ice from roadways (Figure 6). This stockpile is the suspected source of nitrate concentrations (8.6 - 9.6 mg/L) reported for spring SP-17 (DOE 1998), located across (south of) UEFPC and about 100 ft west (upgradient) of well GW-606 (see Section 3.2.2).

Aquifer well GW-380 is completed at a depth of about 15 ft bgs in the Maynardville Limestone approximately 400 ft west (hydraulically upgradient) of New Hope Pond (Figure 6). The unfiltered groundwater samples collected from this well in June and November 1999 contained elevated concentrations of nickel (0.268 and 0.211 mg/L) that exceed the MCL (0.1 mg/L). These results are consistent with historical data for the well, although the nickel concentrations are substantially lower than evident during the early 1990s. In contrast, total nickel concentrations in the two wells clustered with GW-380 (GW-381 and GW-382) rarely exceed respective analytical detection limits; neither trace metal was detected in the

sample collected from well GW-382 in September 1999 (well GW-381 has not been sampled since May 1995). Well GW-380 is constructed with stainless steel well casing and screen and the deeper wells are constructed with steel well casing and an open-hole monitored interval. Considering that nickel concentrations are not elevated in these and other nearby wells and that there are no confirmed sources of these trace metals in the eastern plant area, corrosion of the stainless steel well screen and casing in well GW-380 has been the suspected source of the elevated nickel concentrations (HSW Environmental Consultants, Inc. 1995). Geochemical conditions that are corrosive to stainless steel, such as dissolved oxygen above 2 mg/L (Driscoll 1986), have been evident in the well: the presampling water level in well GW-380 is typically near the midpoint of the screened interval. In addition to chemical corrosion, preliminary microbiological sampling results obtained in May 2000 suggest MIC of the well casing and screen. As shown in Table 15, these preliminary data indicate that the groundwater in well GW-380 contains a complex bacterial consortium whereas well GW-381 generally does not (Jones 2000 a).

**Table 15. Preliminary microbiological sampling results for aquitard wells GW-380 and GW-381**

Well Number	Date Sampled	Bacteria counts (CFU/mL)		
		Iron-Related Bacteria	Sulfate-Reducing Bacteria	Slime-Forming Bacteria
GW-380	05/16/00	>5,000	>10,000	100
	05/16/00 D	>5,000	50,000	100,000
GW-381	05/17/00	<100	<1,000	<100
	05/17/00 D	<100	<100	<100
<b>Note:</b> D = Duplicate sample				

Aquifer wells GW-154 and GW-223 are part of a well cluster in the Maynardville Limestone that is located adjacent to the preconstruction channel of UEFPC on the western side of New Hope Pond about 250 ft east of Building 9720-6 (Figure 6). Well GW-154 is completed at a depth of about 11 ft bgs and well GW-223 is completed at a depth of about 90 ft bgs. Both wells were last sampled in November 1996, and the respective historical data show that each well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater containing elevated concentrations of elemental uranium. Also, uranium concentrations in well GW-154 have been substantially higher than the uranium levels in well GW-223. As shown in the following summary (Table 16), uranium results obtained during CY 1999 are consistent with the respective historical data and show that uranium concentrations in each well exceed the proposed MCL (0.02 mg/L), with total uranium concentration in well GW-154 remaining at least an order-of-magnitude higher than evident in well GW-223.

**Table 16. Selected total uranium results for aquifer wells GW-154 and GW-223, 1986-1999**

Monitoring Well	Total Uranium (mg/L)							
	1986		1990		1996		1999	
	1 <sup>ST</sup> QTR.	3 <sup>RD</sup> QTR.	1 <sup>ST</sup> QTR.	3 <sup>RD</sup> QTR.	1 <sup>ST</sup> QTR.	3 <sup>RD</sup> QTR.	1 <sup>ST</sup> QTR.	3 <sup>RD</sup> QTR.
GW-154	0.021	0.022	2.35	0.751	0.4	0.2	0.267	0.286
GW-223	0.009	0.009	0.001	0.004	0.012	0.02	NS	0.0236
<b>Note:</b> NS = Not sampled								



These results also illustrate the substantial change in uranium concentrations that occurred after closure of New Hope Pond in 1988, with a strongly decreasing concentration trend in well GW-154 (Figure 13) and a strongly increasing concentration trend in well GW-223 (see Section 3.3). These divergent uranium concentration trends generally correspond with distinctive changes in the groundwater elevations in these wells (Figure 13). Before New Hope Pond was closed in 1988 and flow in UEFPC was diverted into Lake Reality, pre-sampling groundwater elevations in these wells reflected consistently upward vertical hydraulic gradients. Following closure of New Hope Pond and initial operation of Lake Reality, the pre-sampling groundwater elevations in these wells have reflected consistently downward vertical hydraulic gradients. The reversal of the vertical hydraulic gradients indicated by the water levels in these wells may be a direct consequence of the closure of the former Oil Skimmer Basin, a 25 x 40 ft sediment-accumulation basin that was associated with operation of New Hope Pond (Figure 3), because visual evidence of a direct hydraulic connection to the basin was observed during installation of wells GW-154 and GW-223 (Geraghty & Miller, Inc. 1989). The former Oil Skimmer Basin is believed to be the source of a distinctive contaminant signature characterized by elevated uranium concentrations along with alpha and beta radioactivity (DOE 1998).

### 3.1.3.2 Volatile Organic Compounds

Excluding false-positive results, one or more chloromethanes (carbon tetrachloride, chloroform, and methylene chloride), chloroethenes (PCE, TCE, c12DCE, t12DCE, 11DCE, and vinyl chloride), chloroethanes (111TCA and 11DCA), petroleum hydrocarbons (benzene, toluene, and dimethylbenzene), several miscellaneous compounds (e.g., bromoform) were detected in at least one groundwater sample collected during CY 1999 from eleven of the wells used for Surveillance Monitoring in the eastern plant area (Table B.3). Maximum CY 1999 summed VOC concentrations are less than 10 µg/L in well GW-380; range from 10 to 100 µg/L in wells GW-148, GW-763, and GW-832; exceed 100 µg/L in wells GW-153, GW-223, GW-383, GW-605, and GW-606; and exceed 1,000 µg/L in wells GW-382 and GW-762 (Table B.3). As shown in the following summary (Table 17), maximum concentrations of PCE, TCE, c12DCE, 11DCE, vinyl chloride, and carbon tetrachloride exceed respective MCLs for drinking water.

**Table 17. Eastern plant area: CY 1999 maximum VOC concentrations that exceed MCLs**

Well Number	CY 1999 Maximum Concentration ( µg/L)					
	PCE	TCE	cis-1,2-DCE	11DCE	Vinyl Chloride	Carbon Tetrachloride
GW-153	7	(2)	<5	<5	<10	<b>280</b>
GW-223	<b>140</b>	<b>41</b>	62	<5	<10	<5
GW-382	<b>110</b>	<b>17</b>	6	(1)	<2	<b>1,900</b>
GW-383	<b>550</b>	<b>160</b>	<b>150</b>	(3)	(2)	<5
GW-605	<b>27</b>	<b>30</b>	55	<5	<2	<b>25</b>
GW-606	<b>8</b>	<5	<5	<5	<2	<b>92</b>
GW-762	<b>1,600</b>	<b>130</b>	61	<b>51</b>	(4)	<5
GW-763	<b>12</b>	(3)	29	<5	(4)	<5
GW-832	<b>6</b>	<5	<5	<5	<2	<b>44</b>
MCL ( µg/L)	5	5	70	7	2	5
<b>Notes:</b> ( ) = Estimated concentration below the reporting limit ND = Not detected Bold = Exceeds MCL						

Dissolved VOCs in these wells originate from one or more source areas (including DNAPL) in the eastern plant area. Closure of New Hope Pond and construction of Lake Reality has strongly influenced the distribution of dissolved VOCs in the eastern plant area, with increasing concentration trends generally evident in wells currently influenced by the UEFPC underdrain and leakage from Lake Reality (DOE 1998).

The DNAPL believed to be present in the subsurface near Building 9720-6 is the suspected source of the dissolved plume of chloroethenes and chloroethanes in the groundwater at aquitard wells GW-762 and GW-763 (DOE 1998). These wells comprise a well cluster in the Nolichucky Shale about 500 ft west of New Hope Pond (Figure 6); well GW-762 is completed at a depth of about 60 ft bgs and well GW-763 is completed at a depth of only 16 ft bgs. Historical data show that PCE and its degradation products (primarily 1,2-DCE isomers) are the principal VOCs present in the groundwater at both wells, although the VOC concentrations in well GW-762, which was last sampled in May 1995, have been at least an order-of-magnitude higher than the VOC concentrations typically evident in well GW-763. The CY 1999 VOC results for these wells are generally consistent with respective historical data and show that the summed maximum VOC concentrations in the shallow groundwater at well GW-763 ( 48 µg/L) remain substantially lower than the summed VOC concentrations evident in the deeper groundwater at well GW-762 (1,852.5 µg/L). Moreover, the PCE concentrations reported for the samples collected from well GW-762 in February 1999 (1,300 µg/L) and August 1999 (1,600 µg/L) are nearly 1% of PCE solubility and clearly suggest DNAPL in the subsurface. Additionally, comparison with historical data for well GW-762 indicates little if any significant difference between VOC results obtained from conventional and low-flow sampling methods. For example, equal concentrations of PCE (1,300 µg/L) were obtained from conventional sampling in May 1995 and low-flow sampling in February 1999. As shown in the following summary (Table 18), however, there are substantial differences between the conventional and low-flow sampling results for well GW-763.

**Table 18. Selected VOC data for aquitard well GW-763, 1995-1999**

VOC	Concentration ( µg/L)									
	Conventional Sampling					Low-Flow Sampling				
	Nov. 1995	June 1996	Nov. 1996	May 1997	Dec. 1997	May 1998	Dec. 1998	May 1999	Nov. 1999	
PCE	19	21	59	35	ND	ND	ND	12	ND	
TCE	5	6	12	8	ND	ND	ND	(3)	ND	
c12DCE	NR	NR	NR	170	ND	ND	ND	29	ND	
t12DCE	NR	NR	NR	(3)	ND	ND	ND	ND	ND	
1,2-DCE (total)	100	75	ND	173	ND	ND	ND	29	ND	
Vinyl chloride	20	12	26	24	(2)	(2)	(2)	(4)	ND	
11DCA	ND	ND	(1)	(2)	ND	ND	ND	ND	ND	
11DCE	ND	ND	(4)	(4)	ND	ND	ND	ND	ND	
SUMMED VOCs:	144	116	112	246	2	2	2	48	0	
<b>Notes:</b> ( ) = Estimated concentration below the reporting limit NR = Not reported ND = Not detected										

The results for conventional sampling may reflect higher VOC concentrations drawn into the well from depth, while the results for low-flow sampling reflect nearby shallow VOC concentrations. The results obtained with either method show that the VOC concentrations in the shallower groundwater at well GW-763 are substantially lower than the VOC concentrations in the deeper groundwater at well GW-762. Unlike

many of the Nolichucky Shale well clusters in the western and central plant areas, presampling groundwater elevations in these wells consistently show downward vertical hydraulic gradients during seasonally high and low flow conditions. Thus, the lower VOC concentrations in well GW-763 may primarily reflect dilution from recharge. Additionally, the lower VOC concentrations in well GW-763 may reflect more efficient biodegradation in the shallower flow system. As shown in Table 19, geochemical conditions in well GW-762 (particularly iron concentrations, dissolved oxygen levels, and REDOX) are less favorable for biodegradation than the geochemical conditions in well GW-763.

**Table 19. CY 1999 results for geochemical parameters indicative of biodegradation in aquitard wells GW-762 and GW-763**

Indicator Parameter/ Optimum Range (Wilson <u>et al.</u> 1996)	GW-762		GW-763	
	Feb. 1999	Aug. 1999	June 1999	Nov. 1999
Nitrate < 1 mg/L	<0.1 mg/L	<0.1 mg/L	<0.028 mg/L	<0.028 mg/L
Iron (II) > 1 mg/L	<0.05 mg/L*	0.848 mg/L*	23.8 mg/L*	21.5 mg/L*
Sulfate < 20 mg/L	15.3 mg/L	16.1 mg/L	1.52 mg/L	1.09 mg/L
REDOX < 50 mV	Not measured	101 mV**	-125 mV**	-124 mV**
Dissolved Oxygen < 0.5 ppm	3.62 ppm**	0.37 ppm**	0.07 ppm**	0.12 ppm**
pH 5 < pH < 9	7.09**	7.06**	6.93**	6.87**
<b>Notes:</b> *Results are for total iron; **Field measurement.				

The DNAPL believed to be present in the subsurface near Building 9720-6 is the suspected source of the dissolved chloroethenes in the groundwater at aquitard well GW-383, which is located near the northwest corner of New Hope Pond about 400 ft northeast (hydraulically downgradient) of wells GW-762 and GW-763 (Figure 6). Historical data show that PCE, TCE, and 1,2-DCE are the primary VOCs in the groundwater at this well, and as illustrated by the selected results summarized below, reflect little if any difference between conventional sampling and low-flow sampling results.

**Table 20. Selected VOC data for aquitard well GW-383, 1995-1999**

VOC	Concentration ( µg/L)								
	Conventional Sampling				Low-Flow Sampling				
	Dec. 1995	June 1996	Nov. 1996	May 1997	Dec. 1997	June 1998	Dec. 1998	May 1999	Nov. 1999
PCE	380	350	500	350	310	400	440	350	550
TCE	150	150	200	180	100	150	170	150	160
c12DCE	NR	NR	NR	130	100	110	120	150	140
t12DCE	NR	NR	NR	(2)	(1)	(1)	(2)	ND	ND
12DCE (total)	120	99	120	132	101	111	122	150	140
Vinyl chloride	ND	(2)	ND	(4)	ND	(2)	(2)	(2)	ND
SUMMED VOCs:	650	599	820	666	511	663	734	652	850
<b>Notes:</b> ( ) = Estimated concentration below the reporting limit NR = Not reported ND = Not detected									

Additionally, results obtained since August 1988 indicate a moderately increasing long-term trend for PCE in the groundwater at this well (see Section 3.3).

Aquitard well GW-148 is located between New Hope Pond and Lake Reality near the geologic contact between the Nolichucky Shale and Maynardville Limestone (Figure 6). This well is completed at a depth of about 12 ft bgs and historical data show that it typically yields calcium-magnesium-bicarbonate containing relatively low concentrations of 1,2-DCE (i.e., substantially below the 70 µg/L MCL). Concentrations of c12DCE detected in the groundwater samples collected from the well in June 1999 (20 µg/L) and November 1999 (17 µg/L) are consistent with the historical data and reflect a generally increasing long-term concentration trend (see Section 3.3).

Well GW-832 is located on the northeast side of New Hope Pond about 400 ft east-southeast of well GW-148 (Figure 6). This shallow well (12 ft bgs), which intercepts the gravel underdrain beneath the distribution channel, was completed with 6-inch well casing and was used as the pumping well for a short-term pumping test performed in May 1996; results of the pumping test demonstrated a direct hydraulic connection between the well and the Lake Reality Sump (AJA 1997). Sampling results obtained during CY 1999 show that the well yields (sulfate-enriched) calcium-magnesium-bicarbonate groundwater containing fairly moderate concentrations of carbon tetrachloride (44 µg/L) along with low levels of chloroform (5 µg/L) and PCE (6 µg/L). As shown in the following summary (Table 21), the carbon tetrachloride concentrations in the CY 1999 samples are higher than the historical results reported for well GW-832 which may reflect a delayed response to the staged pumping test completed about a week before the well was sampled in July 1998 (see Section 2.3).

**Table 21. Selected VOC data for aquitard well GW-832, 1996-1999**

VOC	Concentration ( µg/L)					
	Conventional Sampling		Low-Flow Sampling			
	May 1996	April 1997	Feb. 1998	July 1998	Feb. 1999	Aug. 1999
Carbon tetrachloride	<b>23</b>	<b>20</b>	<b>21</b>	<b>19</b>	<b>44</b>	<b>44</b>
Chloroform	(3)	(4)	(3)	(4)	5	5
PCE	<b>6</b>	ND	<b>7</b>	(3)	<b>6</b>	<b>6</b>
TCE	(1)	(1)	(1)	ND	ND	ND
<b>Notes:</b> ( ) = Estimated concentration below the reporting limit ND = Not detected; BOLD = exceeds MCL						

However, results for the other compounds are consistent with the historical data for well GW-832, and suggest relatively stable long-term VOC concentration trends in the shallow groundwater at the well.

The CY 1999 VOC results for aquifer well GW-605 support data obtained during CY 1998 that indicated a substantial divergence from the historical VOC data for the well. Historical results for the well show that peak concentrations of PCE (65 µg/L), TCE (25 µg/L), and c12DCE (54 µg/L) evident in September 1995 steadily decreased below respective analytical reporting limits (5 µg/L) in March 1998. As shown in Table 22, however, results obtained since July 1998 show much higher PCE, TCE, and c12DCE levels.

**Table 22. Selected chloroethene data for aquifer well GW-605, 1995-1999**

VOC	Concentration ( µg/L)								
	Conventional Sampling					Low-Flow Sampling			
	Sep. 1995	Feb. 1996	June 1996	Mar. 1997	Aug. 1997	Mar. 1998	July 1998	Feb. 1999	July 1999
PCE	65	21	14	(3)	7	ND	35	12	27
TCE	25	8	5	(1)	(2)	ND	43	14	30
c12DCE	54	21	13	(3)	5	ND	79	24	55
<b>Notes:</b> ( ) = Estimated concentration below analytical reporting limit ND = Not detected									

This abrupt increase in the concentration of these chloroethenes does not appear to be a sampling artifact because, as shown in the preceding data summary, similar concentrations of each compound have been detected in samples obtained using the conventional and low-flow sampling methods. Alternatively, the increased concentration of chloroethenes in the shallow groundwater at this well may potentially reflect the influence of the stepped pumping test described in Section 2.3, which was completed nine days before the well was sampled in July 1998. Increased relative flux of shallow groundwater in response to the pumping test may have flushed chloroethenes into the flow system near the well.

Groundwater in well GW-605 also contains dissolved chloromethanes, primarily carbon tetrachloride and chloroform, that may originate from historical spills west of New Hope Pond (SAIC 1998) along a rail line on the north side and parallel to UEFPC (Figure 6). Historical data show that the concentration of carbon tetrachloride in well GW-605 steadily increased from 26 µg/L in August 1991 to a peak concentration of 320 µg/L in June 1995, subsequently decreased to 170 µg/L in August 1997, then abruptly dropped to 4 µg/L in March 1998 and has subsequently remained below 50 µg/L. As shown in the following summary (Table 23), the sharp decrease in the concentration of carbon tetrachloride coincides with the change from conventional sampling to low flow sampling.

**Table 23. Selected chloromethane data for aquifer well GW-605, 1995-1999**

VOC	Concentration ( µg/L)								
	Conventional Sampling					Low-Flow Sampling			
	June 1995	Feb. 1996	June 1996	Mar. 1997	Aug. 1997	Mar. 1998	July 1998	Feb. 1999	July 1999
Carbon tetrachloride	320	190	250	100	170	(4)	42	10	25
Chloroform	35	26	23	FP	16	ND	11	12	11
<b>Notes:</b> ( ) = Estimated concentration below analytical reporting limit FP = False positive ND = Not detected									

Thus, it is not clear if the decreasing concentration trend indicated by the carbon tetrachloride (and chloroform) results for the well (Figure 12) is an artifact of the change in the sampling method or if the trend indicates reduced flux of these compounds along the groundwater flowpaths intercepted by well GW-605.

The CY 1999 VOC results for aquifer well GW-606 are consistent with historical data showing that carbon tetrachloride and chloroform, along with trace levels of PCE, are the principal components of the dissolved VOC plume at intermediate depths in the Maynardville Limestone. As noted previously, maximum CY 1999 carbon tetrachloride and PCE concentrations in well GW-606 remain above respective MCLs. Nevertheless, the CY 1999 results also continue the decreasing long-term concentration trends illustrated by historical carbon tetrachloride data for the well (Figure 12). These decreasing trends are accompanied by widely fluctuating but generally increasing proportions of chloroform relative to carbon tetrachloride; chloroform concentrations in the samples collected from the well in CY 1998 exceed 100 µg/L, and chloroform concentrations in the samples collected from the well in CY 1999 exceed 200 µg/L. Increasing proportions of chloroform indicate that the decreasing carbon tetrachloride concentrations are at least partially attributable to biotic and/or abiotic degradation. However, considering the evidence of a direct hydraulic connection with UEFPC observed during installation of well GW-606, and the long-term rise in the groundwater elevation in the well, which has increased about 1 ft since the early 1990s, dilution is probably the primary natural attenuation mechanism (DOE 1998).

As noted previously in Section 3.1.3.1, aquifer well GW-382 is part of a three-well cluster in the Maynardville Limestone located about 400 ft along strike to the west (hydraulically upgradient) of New Hope Pond (Figure 6). This well is completed with an open-hole interval about 60 ft bgs, and historical data show that it yields calcium-magnesium-bicarbonate groundwater containing a suite of dissolved VOCs dominated by carbon tetrachloride, chloroform, and PCE. The very high (>1,500 µg/L) carbon tetrachloride concentration at well GW-382 suggests migration from suspected DNAPL potentially originating from a spill along the rail line south of Building 9720-6 (SAIC 1998). Analytical results for the groundwater sample collected from the well in September 1999 are consistent with these historical data and show that the concentrations of carbon tetrachloride (1,900 µg/L), chloroform (920 µg/L) and PCE (110 µg/L) remain very high, but do not clearly reflect an increasing or decreasing long-term trend (Table B.4). For example, similar levels of carbon tetrachloride (1,500 µg/L), chloroform (950 µg/L) and PCE (130 µg/L) were reported for the groundwater sample collected from this well in January 1993. The CY 1999 results for well GW-382 are also similar to historical VOC data with respect to the relatively low concentration of PCE degradation products. For instance, TCE and 1,2-DCE isomers have been detected in few of the samples collected from the well and the concentrations of these compounds have not exceeded 50 µg/L. This suggests minimal biodegradation of the dissolved chloroethenes in the groundwater at this well.

Aquifer well GW-223 is located about 400 ft northeast (hydraulically downgradient) of aquifer well GW-382 (Figure 6). Historical data show that the groundwater in this well contains a plume of dissolved VOCs consisting primarily of chloroethenes (PCE, TCE, and 1,2-DCE) with lesser amounts of chloromethanes (carbon tetrachloride and chloroform). Analytical results for the groundwater sample collected from this well in September 1999 show that the concentrations of PCE (140 µg/L) and TCE (41 µg/L) have decreased substantially from the respective concentrations (420 µg/L and 110 µg/L) evident when the well was last sampled in November 1996 (Figure 13). Similar decreasing trends also are evident for carbon tetrachloride and chloroform (neither compound was detected in the groundwater sample collected in September 1999). The decreased VOC concentrations in the groundwater at well GW-223 possibly reflect reduced flux of these VOCs (PCE, TCE, and chloromethanes) and dilution from inflow of relatively uncontaminated recharge (see discussion in Section 3.1.3.1).

Aquifer well GW-153 is located about 800 ft east (downgradient) of well GW-382 and 200 ft directly south (across geologic strike) of New Hope Pond (Figure 6). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater from the shallow (<100 ft bgs) flow system in the Maynardville Limestone. The CY 1999 results for well GW-153 are consistent with historical data and show that carbon tetrachloride is the principal component of the dissolved VOC plume in the groundwater at the well, and that the maximum concentrations of carbon tetrachloride (270 µg/L) and PCE (7 µg/L) remain above the respective MCL. Additionally, these results continue the increasing long-term concentration trend evident

for carbon tetrachloride (see Section 3.3) and the indeterminate long-term concentration trend evident for PCE.

### 3.1.3.3 Radioactivity

Historical monitoring data do not indicate widespread radiological contamination in the eastern plant area. Results for the network of Surveillance Monitoring wells sampled during CY 1999 are consistent with these historical findings. As shown in Table 24, gross alpha and gross beta results that exceed the corresponding MDA were reported for at least one groundwater sample collected during CY 1999 from eight of the Surveillance Monitoring wells in the eastern plant area.

**Table 24. Eastern plant area: CY 1999 gross alpha and gross beta results that exceed MDAs**

Well	Date Sampled	Gross Alpha (pCi/L)				Gross Beta (pCi/L)			
		MDA	Activity ± CE			MDA	Activity ± CE		
GW-154	02/10/99	1.03	461	±	12.6	2.48	77.13	±	3.31
	08/30/99	3.15	432	±	15.3	2.59	55.49	±	3.24
GW-223	09/07/99	3.4	16	±	5.5	8.9	9.4	±	5.8
GW-382	09/02/99	1.7	2.4	±	1.24	2.03	6.52	±	1.44
GW-383	11/11/99	3.7	<MDA			6	7.4	±	4.1
GW-605	02/11/99	2.35	39.27	±	3.56	2.16	17.73	±	1.77
	07/20/99	1.99	51.18	±	5.3	1.91	31.79	±	2.3
GW-606	02/15/99	2.05	6.74	±	2.04	1.94	5.3	±	1.35
	07/21/99	1.5	4.22	±	1.52	2.18	3.89	±	1.41
GW-762	02/09/99	0.93	1.96	±	0.88	2.13	<MDA		
	08/24/99	2.61	<MDA			2.31	2.56	±	1.45
GW-832	02/09/99	0.9	6.27	±	1.43	2.61	<MDA		
	08/31/99	1.68	1.87	±	1.15	2.12	<MDA		

**Note:** Bold = Activity exceeds MCL

As noted in Section 3.1.3.1, aquifer well GW-605 monitors a distinctive plume of radiological contamination in the Maynardville Limestone that originates from an unidentified but presumably nearby source area (DOE 1998). Historical data for this well show that alpha (and beta) radioactivity is from uranium isotopes (U-234 and U-238). The CY 1999 results show that, although above the MCL for drinking water (15 pCi/L), gross alpha activity remains substantially below the level evident in March 1998 (130 pCi/L), with the gross alpha results obtained in July 1998 (29 pCi/L) and February 1999 (39 pCi/L) being the lowest levels reported since the well was first sampled in August 1991 (47 pCi/L). As noted in Section 3.1.3.1, a similarly sharp decrease in total uranium concentrations also is indicated by the results obtained since July 1998, which potentially reflects the influence of the pumping test described in Section 2.3.

As shown in the preceding data summary, the highest gross alpha and gross beta activities were reported for the groundwater samples collected from aquifer well GW-154 during seasonally high (February 1999) and seasonally low (August 1999) groundwater flow conditions. Analytical results these samples show that alpha and beta radioactivity in the shallow groundwater at this well is primarily from U-234 ( $543 \pm 133$  pCi/L and  $535 \pm 151$  pCi/L) and U-238 ( $97 \pm 24$  pCi/L and  $140 \pm 40$  pCi/L). Historical gross alpha results indicate fairly indeterminate long-term trend whereas the gross beta results reflect a generally decreasing long-term trend that closely mirrors that of elemental uranium (Figure 13). As with elemental uranium, the reduced

levels of beta radioactivity is probably a direct consequence of the closure the former Oil Skimmer Basin and subsequent recharge/flushing in the shallow flow system (see Section 3.1.3.1).

### **3.1.4 Union Valley**

Monitoring results obtained from six monitoring wells (GW-169, GW-170, GW-151, GW-172, GW-230, and GW-232) and three springs (SCR 7.1SP, SCR7.18SP, and SCR7.8SP) located in Union Valley east of the Y-12 Plant (Figure 6) were evaluated for the purposes of CY 1999 Surveillance Monitoring in the East Fork Regime. Review of these results indicates that contaminants (VOCs) were detected in the groundwater samples collected from wells GW-169, GW-170, and GW-230 and from each of the springs. The maximum VOC concentrations reported for well GW-169 (PCE and TCE) and springs SCR7.1SP (carbon tetrachloride and chloroform), SCR7.18SP (111TCA and 11DCA), and SCR7.8SP (PCE, c12DCE, 111TCA, and 11DCA) are estimated values below 5 µg/L. Concentrations of VOCs reported only for wells GW-170 (carbon tetrachloride and chloroform) and GW-230 (c12DCE) exceed reporting limits.

Intermediate depth aquifer well GW-170 (104 - 156.9 ft bgs) is clustered with shallow well GW-169 (29 - 35 ft bgs) and deep well GW-232 (401 - 411.7 ft bgs). The well is located about 1,500 ft east of the ORR boundary along Scarboro Road (Figure 6) and is about 3,700 ft east of the nearest confirmed source of VOCs (Building 9720-6) at the Y-12 Plant. Historical data show that this well yields calcium-magnesium-bicarbonate groundwater containing a mixture of dissolved chloroethenes (primarily PCE and TCE) and chloromethanes (carbon tetrachloride, chloroform, and methylene chloride). Results obtained during CY 1999 are consistent with the historical data and show carbon tetrachloride concentrations (31 - 57 µg/L) remain above the MCL (5 µg/L) along with relatively low chloroform concentrations (12 -14 µg/L) and trace levels (<5 µg/L) of PCE and TCE. Combined with the historical data for the well, these VOC results reflect relatively stable or indeterminate long-term concentration trends. For example, TCE concentrations ranging from 2 to 4 µg/L have been detected in 22 of the 23 samples collected from the well between March 1991 and August 1999.

Deep aquifer well GW-230 (341 - 406.4 ft bgs), clustered with shallower wells GW-171 (26 - 31.2 ft bgs) and GW-172 (105 - 133.8 ft bgs), is located about 4,000 ft east of the ORR boundary along Scarboro Road (Figure 6) and about 6,200 ft east of the nearest confirmed source of VOCs (Building 9720-6) at the Y-12 Plant. Historical data show that this well yields sulfate-enriched calcium-magnesium-bicarbonate groundwater containing dissolved VOCs (primarily 1,2-DCE). Chloroethenes (c12DCE and vinyl chloride) along with acetone, 2-butanone, and toluene were detected in the groundwater samples collected from the well during CY 1999; however, the maximum concentration of each compound except c12DCE is an estimated value below 5 µg/L (Table B.3). Along with the historical data for the well, these VOC results reflect relatively stable or indeterminate long-term concentration trends. For example, the maximum CY 1999 concentrations of c12DCE (12 µg/L), vinyl chloride (2 µg/L), and toluene (1 µg/L) are very similar to the concentrations of (total) 1,2-DCE (13 µg/L), vinyl chloride (4 µg/L), and toluene (3 µg/L) reported the last time the well was sampled (June 1996).

## **3.2 Exit Pathway/Perimeter Monitoring Evaluation**

As shown in Table 25, the CY 1999 sampling results reported for 12 monitoring wells and nine surface water sampling locations were evaluated for the purposes of Exit Pathway/Perimeter Monitoring in East Fork Regime.



**Table 25. Network of sampling locations used for CY 1999 Exit Pathway/Perimeter Monitoring in the East Fork Regime**

Groundwater		Surface Water	
GW-131	GW-733	OF 195	SP-17
GW-151	GW-735	OF 221	LRSPW
GW-207	GW-744	OF 225	STATION 17
GW-208	GW-747	OF 200	
GW-220	GW-750	OF 51	
GW-722	GW-816	STATION 8	

In addition to these locations in the East Fork Regime, surface water samples were collected once during CY 1999 from four sampling stations (GHK2.51ESW, GHK2.51WSW, NPR07.0SW and NPR12.0SW) located north of Pine Ridge along the ORR Boundary (Table B.2). The results for these samples indicate that the surface water at these locations is not contaminated.

All of the monitoring wells are located in the eastern plant area and are hydraulically downgradient to the north/northeast or east/southeast of New Hope Pond, and all but two of the wells (GW-151 and GW-220) are located within 500 ft of the ORR boundary along Scarboro Road (Figure 6). The surface water sampling stations include the outfall for three storm drains in the western plant area near the Y-12 Salvage Yard (OF 195, OF 221, and OF 225); OF 200, Station 8, and OF 51 in the central plant area; spring-17 (SP-17), LRSPW, and Station 17 in the eastern plant area.

Each of the monitoring wells used for Exit Pathway/Perimeter Monitoring except GW-131 were sampled semiannually during CY 1999; well GW-131 was sampled only once (Table B.2). The low-flow sampling procedure described in Section 3.1 was used to obtain samples from all of the wells except GW-131 and GW-722, which were sampled in accordance with the operating procedures and manufacturers instructions for the multiport sampling equipment (Westbay™) in each well. Samples were collected semiannually during CY 1999 from each of the surface water sampling locations except Stations 8 and 17, which were sampled four times during the year (Table B.2). The groundwater and surface water samples collected from each CY 1999 sampling location were analyzed for inorganics (major ions and trace metals), VOCs, and selected radioanalytes. These analytical results, along with historical data for each sampling location, serve as the basis for the following evaluation of groundwater and surface water quality where contaminants from the Y-12 Plant are most likely to migrate beyond the ORR property line.

### 3.2.1 Groundwater

The groundwater samples collected from most of the monitoring locations used for Exit Pathway/Perimeter Monitoring during CY 1999 show no indication of contamination (wells GW-207, GW-208, GW-735, GW-744, GW-747, GW-750, GW-816, and the 10 sampling ports of well GW-131). Contaminants originating from sources within the Y-12 Plant were detected in groundwater samples collected from four of the monitoring wells: wells GW-151, GW-220, GW-722, and GW-733 (Table B.4). Dissolved VOCs in the groundwater at wells GW-151 and GW-220 originate from one or more of the source areas within the Y-12 Plant, and the concentration and distribution of these VOCs was substantially influenced by the closure of New Hope Pond and the construction/operation of Lake Reality. Wells GW-722 and GW-733 monitor the carbon tetrachloride dominated plume of dissolved VOCs in the Maynardville Limestone that originates upgradient (west) of wells GW-605/GW-606 and extends along geologic strike into Union Valley east of the ORR boundary along Scarboro Road (Figure 5).

Aquifer wells GW-151 and GW-220 comprise a well cluster located about 200 ft directly east (hydraulically downgradient) of New Hope Pond (Figure 6). Both wells yield calcium-magnesium-bicarbonate groundwater from the lower Maynardville Limestone at depths of about 97 ft bgs (GW-151) and 45 ft bgs (GW-220). Historical data show that both wells monitor a plume of dissolved chloromethanes (primarily carbon tetrachloride) with lesser amounts of dissolved chloroethenes (primarily PCE). The CY 1999 sampling results for well GW-151, which was last sampled in November 1996, show that the maximum concentrations of PCE (80 µg/L), TCE (25 µg/L), carbon tetrachloride (1,000 µg/L), and methylene chloride (90 µg/L) remain above respective MCLs. Similarly, the maximum concentrations of PCE (70 µg/L), TCE (13 µg/L), carbon tetrachloride (620 µg/L) detected in the samples collected from well GW-220 during CY 1999 also remain substantially above the respective MCL. Additionally, the CY 1999 VOC results for these wells continue the clearly increasing long-term concentration trends evident in each well (see Section 3.3).

Aquifer well GW-722 is located about 1,000 ft east (downgradient) of New Hope Pond approximately 500 ft west (upgradient) of the ORR boundary (Figure 6). This well is completed with a 500 ft open-hole interval in the Maynardville Limestone and, as noted previously, is equipped with a multiport sampling system that enables collection of discrete groundwater samples from multiple depths within the open-hole interval. In CY 1999, groundwater samples were collected from 10 sampling ports (numbered in ascending order from deepest to shallowest) ranging in depth from 90 to about 563 ft bgs (Table B.2). Historical data show that several of these sampling ports intercept the primary strike-parallel migration pathways for the dissolved plume of carbon tetrachloride that originates upgradient (west) of aquifer wells GW-605/GW-606 and extends along strike beneath New Hope Pond into Union Valley east of the ORR boundary (Figure 5). As shown in the following summary (Table 26), one or more VOCs were detected in at least one of the groundwater samples collected during CY 1999 from all but two of the sampling ports (06 and 30), with the highest summed VOC concentrations (>250 µg/L) evident in sampling ports 14, 17, 20, and 22 (i.e., between 300 ft and 450 ft bgs).

**Table 26. Summary of CY 1999 VOC results for aquifer well GW-722**

Sampling Port No. and Depth (ft bgs)		CY 1999 Maximum Summed Concentration ( µg/L)				
		Chloroethenes	Chloromethanes	Chloroethanes	Petroleum Hydrocarbons	Misc. Compounds
33	90	.	(1)	.	.	.
32	110	.	(1)	.	.	.
30	153.9	.	.	.	.	.
26	218.9	.	.	.	(10)	.
22	315.8	37	506	.	.	5
20	335.8	49	273	.	.	(4)
17	387.7	66	747	.	.	7
14	427.7	47	610	(2)	.	6
10	502.6	8	52	.	.	.
06	562.6	.	.	.	.	.
<b>Note:</b> ( ) = Estimated concentration below analytical reporting limit						

Compounds detected in at least one sample collected from these sampling ports include PCE, TCE, c12DCE, 11DCE, carbon tetrachloride, chloroform, 111TCA, benzene, toluene, acetone, carbon disulfide, styrene, and trichlorofluoromethane. As shown in Table 27, maximum concentrations of PCE, TCE, and carbon tetrachloride remain above respective MCLs.

**Table 27. CY 1999 VOC concentrations in well GW-722 that exceed MCLs**

Sampling Port	CY 1999 Maximum Concentration ( µg/L)		
	PCE	TCE	Carbon Tetrachloride
22	<b>35</b>	5	<b>470</b>
20	<b>41</b>	5	<b>230</b>
17	<b>53</b>	7	<b>700</b>
14	<b>36</b>	<b>6</b>	<b>560</b>
10	7	(2)	<b>36</b>
MCL ( µg/L)	5	5	5
<b>Note:</b> “.” = Not Detected; ( ) = Estimated concentration; Bold = Exceeds MCL.			

In addition to dissolved chlorinated solvents, the groundwater samples collected during CY 1999 from sampling ports 06, 26, and 30 in well GW-722 contained acrylonitrile concentrations ranging from 2 µg/L (port 33) to 20 µg/L (port 26). Acrylonitrile was detected at similar concentrations in the groundwater samples collected from these ports during CYs 1997 and 1998. According to the manufacturer, the Westbay™ sampling system contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999). Detection of acrylonitrile in the groundwater from these sampling ports in well GW-722 (particularly the high concentrations in the samples from sampling port 26) suggests that they monitor low-permeability intervals in the Maynardville Limestone.

The persistent detection of dissolved petroleum hydrocarbons in the groundwater from sampling port 26 is another conspicuous characteristic of the VOC data for well GW-722. Trace levels (1 - 3 µg/L) of benzene, toluene, and a biodegradation product of ethylbenzene (styrene), were detected in the groundwater samples collected from the port during CY 1999. These petroleum hydrocarbons (and styrene) also were detected in the samples collected from this port during CYs 1997 and 1998. It is difficult to explain the presence of dissolved petroleum hydrocarbons in the groundwater from sampling port 26 considering: (1) the depth of the port in well GW-722 (about 219 ft bgs); (2) the distance to well GW-722 from known sources of petroleum hydrocarbons (e.g., Tank 2331-U in the central plant area) and the substantial attenuation that would be expected during transport from the source area(s); (3) the general lack of chloroethenes and chloromethanes in samples from this port (i.e., the primary VOCs in groundwater from deeper sampling ports in the well); (4) the low permeability of the monitored interval potentially indicated by the consistent detection of acrylonitrile in the samples from the port; and (5) the overall lack of petroleum hydrocarbons in other shallow and intermediate depth Maynardville Limestone wells upgradient to the west (along geologic strike) of New Hope Pond.

Aside from VOCs, groundwater samples from sampling ports 14, 17, 20, and 22 in well GW-722 are also distinguished by elevated nitrate concentrations. Results for each of the samples collected from these ports during CY 1999 show nitrate concentrations above 1 mg/L, with the highest levels reported for samples collected in March 1999 (i.e., seasonally high flow) from ports 14 (2.66 mg/L) and 17 (2.53 mg/L). Although these nitrate concentrations do not exceed the MCL (10 mg/L), they are at least an order-of-magnitude higher than background levels in the Maynardville Limestone (e.g., <0.028 mg/L in sampling port 33). As noted in Sections 3.1.1.1 and 3.1.3.1, elevated nitrate concentrations in the East Fork Regime are believed to reflect migration from the contaminant plume emplaced in the western plant area during operation of the former S-3 Ponds and/or the S-2 Site, with possible contribution from the former stockpile of urea in the eastern plant area.

Aquifer well GW-733 is located southeast (across geologic strike) of well GW-722 about 500 ft west of the ORR property boundary along Scarboro Road (Figure 6). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater from the upper Maynardville Limestone that sporadically contains trace levels (<5 µg/L) of dissolved chloroethenes (primarily PCE) along with much higher (<100 µg/L) but generally decreasing concentrations of dissolved chloromethanes (primarily carbon tetrachloride). The CY 1999 results for well GW-733 are consistent with these historical findings and continue the decreasing VOC concentration trends evident since the mid 1990s (Figure 12). For example, carbon tetrachloride concentrations decreased about 91% between November 1993 (87 µg/L) and July 1999 (8 µg/L). Decreasing VOC concentrations in well GW-733 may be primarily attributable to hydrologic attenuation mechanisms (e.g., dilution and dispersion) because the consistently low proportions of chloroform relative to carbon tetrachloride (and infrequent detection of PCE degradation products) suggest minimal biotic and/or abiotic degradation in the groundwater.

### 3.2.2 Surface Water

One or more inorganic, organic, and radiological contaminants originating from sources within the Y-12 Plant were detected in at least one of the samples collected from all of the surface water sampling locations used for Exit-Pathway/Perimeter monitoring during CY 1999 (Table 28, the sampling locations are arranged in order from upstream to downstream).

**Table 28. Types of contaminants detected at surface water sampling locations used for Exit-Pathway/Perimeter Monitoring during CY 1999**

Sampling Location	Inorganics	Organics	Radiological
OF 225	°	.	°
OF 221	°	.	°
OF 195	°	.	°
OF 200	°	.	.
STATION 8	°	°	°
OF 51	°	°	.
SP-17	°	.	.
LRSPW	°	.	.
STATION 17	°	.	.

Inorganic contaminants detected in the samples were boron, chloride, iron, manganese, mercury, nitrate, sulfate, and uranium; however, nitrate, sulfate, mercury, and uranium were detected the most frequently in the samples collected from the CY 1999 surface water sampling locations. As shown in Table 29, the highest concentration of each of these contaminants except mercury were reported for the samples collected from outfalls in the western plant area (OF 225, OF 221, and OF 195).

**Table 29. Surface water exit pathway: maximum CY 1999 nitrate, sulfate, mercury, and uranium concentrations**

Sampling Location	Maximum CY 1999 Concentration (mg/L)			
	Nitrate (as N)	Sulfate	Mercury	Uranium
OF 225	<b>112</b>	39.3	0.0002	<b>0.145</b>
OF 221	9.4	27.3	ND	<b>0.406</b>
OF 195	<b>40.6</b>	33.2	ND	<b>0.0667</b>
OF 200	5.7	41.5	0.0007	<b>0.261</b>
STATION 8	3.9	34	0.00081	<b>0.169</b>
OF 51	4.8	20.1	0.0018	ND
SP-17	9.6	4.5	ND	ND
LRSPW	1.5	25.9	ND	0.00538
STATION 17	3	25.6	0.001	<b>0.069</b>
<b>Note:</b> ND = Not detected BOLD = Exceeds current or proposed (uranium) MCL				

Note also that the nitrate concentrations reported for OF 225 and OF 195 exceed the MCL (10 mg/L) and nearly exceed the MCL at spring SP-17. Migration from the contaminant plume emplaced during operation of the former S-3 Ponds is the suspected source of the nitrate in the outfalls, but a former stockpile of urea used to remove ice from road surfaces is the probable source of nitrate in SP-17 (DOE 1998). This stockpile was located on the flank of Chestnut Ridge southwest (upgradient) of the spring and also may be the source of nitrate at nearby well GW-606 (see Section 3.1.3.1) and GW-722 (see Section 3.2.1).

Total uranium concentrations reported for each of the surface water sampling locations except OF 51, SP-17, and the LRSPW exceed the proposed federal MCL for uranium (0.02 mg/L). The uranium concentrations are highly variable (range covers more than an order of magnitude) at the six sampling locations with concentrations that exceed 0.02 mg/L. At the outfalls in the western plant area (OF 195, OF 221, and OF 225) uranium concentrations were elevated in the April samples but were not detected in the September samples. Additionally, the maximum CY 1999 uranium concentrations (Table 29) reported for OF 200, Station 8, and Station 17 were in samples collected within six hours after a significant storm event in July (Table B.2). Migration from the contaminant plume emplaced during operation of the former S-3 Ponds may be a source of the uranium detected in the outfalls in the western plant area; other source areas in the central and eastern plant areas are the likely source of the uranium in OF 200, Station 8, and Station 17.

Five of the surface water sampling locations (OF 200, Station 8, OF 51, LRSPW, and Station 17) had samples that contained dissolved VOCs (Table B.3), primarily chloroethenes (PCE, TCE, and c12DCE) and chloromethanes (carbon tetrachloride and chloroform). Samples from OF 195, OF 221, and OF 225 were not analyzed for VOCs, and none were detected in samples from SP-17. Most of the VOC results were estimated values below 5 µg/L. However, the maximum CY 1999 concentrations of PCE, TCE, and carbon tetrachloride exceeded the respective MCLs (5 µg/L each) in samples from two locations: PCE (16 µg/L) and TCE (6 µg/L) at OF 51, and PCE (7 µg/L) and carbon tetrachloride (50 µg/L) at LRSPW. The VOC plume intercepted by the buried headwaters of UEFPC and tributaries (BT-1, BT-2, BT-3, BT-4, and BT-5) contributes VOCs to OF 51 (Figure 3), and the predominantly carbon tetrachloride plume in the eastern plant area is the source of VOCs at LRSPW.

Historically, the samples from LRSPW were commingled water from the spillway (UEFPC) and the underdrain of the UEFPC distribution channel. However, beginning in CY 1999 the sampling method was changed; the spillway is closed during sample collection and the sample is collected directly from the outfall

of the UEFPC distribution channel underdrain. As a result of the new sample collection method, the CY 1999 samples from LRSPW had the highest carbon tetrachloride concentrations (50 µg/L and 31 µg/L) reported for the location.

As shown in Table 30, gross alpha and gross beta results that exceed the corresponding MDA were reported for at least one groundwater sample collected from six of the surface water sampling locations used for Exit Pathway/Perimeter Monitoring during CY 1999.

**Table 30. Surface water exit-pathway: CY 1999 gross alpha and gross beta results that exceed MDAs**

Sampling Location	Date Sampled	Gross Alpha (pCi/L)			Gross Beta (pCi/L)		
		MDA	Activity ± CE		MDA	Activity ± CE	
OF 225	04/28/99	3.32	<b>92.13</b>	± 7.72	2.88	<b>296.4</b>	± 6.61
	09/21/99	1	1.77	± 0.77	1.22	4.88	± 0.9
OF 221	04/28/99	1.71	<b>244.4</b>	± 8.23	1.95	<b>71.6</b>	± 2.79
	09/21/99	1.67	3.35	± 1.29	1.8	11.1	± 1.45
OF 195	04/28/99	3.08	<b>51.73</b>	± 5.16	2	<b>111</b>	± 3.54
	09/21/99	1.52	3.72	± 1.23	1.57	14.02	± 1.4
STATION 8	02/12/99	0.97	7.89	± 1.91	1.69	6.41	± 1.31
	07/12/99	1.76	<b>54.97</b>	± 4.55	1.9	36.22	± 2.37
	07/15/99	1.89	11.07	± 2.33	1.71	7.12	± 1.36
OF 51	02/10/99	0.72	4.82	± 1.12	1.64	1.77	± 1.01
	08/17/99	1.99	3.77	± 1.6	1.82	<MDA	
SP-17	02/10/99	0.8	3	± 0.97	2.05	<MDA	
	08/17/99	2.14	<MDA 3		1.83	<MDA	

**Note:** Bold = Activity exceeds MCL

Analytical results obtained during CY 1999 show that uranium isotopes account for the elevated gross alpha and gross beta activity reported for most of the surface water sampling. However, it is possible that Tc-99 may contribute to the beta radioactivity, particularly in the outfalls located within the western plant area (samples collected from each outfall during CY 1999 were not analyzed for Tc-99). For instance, the relatively low levels of U-234 ( $44 \pm 12$  pCi/L) and U-238 ( $53 \pm 14$  pCi/L) reported for the sample collected from OF 225 in April 1999 do not account for the much higher level of gross beta activity ( $296 \pm 6.6$  pCi/L) reported for this sample.

### 3.3 Contaminant Concentration Trends

Monitoring data obtained since the late 1980s and early 1990s show indeterminant or generally decreasing long-term contaminant concentration trends for the majority of sampling locations in the East Fork Regime, including most of the CY 1999 sampling locations in the western, central, and eastern plant areas (Table B.5). Indeterminant trends occur at monitoring locations where insufficient data are available, the trend is fairly stable, or concentrations fluctuate with no apparent linear trend over time. The decreasing concentration trends probably reflect a combination of several factors, including compliance with waste management regulations, waste minimization and source control measures, remedial actions, natural attenuation mechanisms, and, in some cases, changes in sampling procedures and analytical methods. For the purposes of DOE Order 5400.1A requirements, the following discussion is focused on CY 1999 sampling locations that clearly exhibit increasing long-term contaminant concentration trends.

As shown in Table 31, increasing long-term contaminant concentration trends are indicated by the monitoring data for ten of the CY 1999 sampling locations in the East Fork Regime, including two wells in the western plant area, two wells in the central plant area, and six wells in the eastern plant area.

**Table 31. Monitoring wells sampled during CY 1999 that exhibit increasing long-term contaminant concentration trends**

Monitoring Well	Increasing Long-Term Concentration Trends			Figure Number
	Inorganics	VOCs	Radioactivity	
<b>Western Plant Area</b>				
GW-108	.	.	°	14
GW-253	.	.	.	15
<b>Central Plant Area</b>				
GW-204	°	.	°	16
GW-782	.	.	°	17
<b>Eastern Plant Area</b>				
GW-148	.	°	.	18
GW-151	.	°	.	19
GW-153	.	°	.	20
GW-220	.	°	.	19
GW-223	.	°	.	21
GW-383	.	°	.	18

Monitoring results for aquitard well GW-108 show that Tc-99 activities increased more than 500% between March 1988 (4,444 pCi/L) and July 1998 ( $23,000 \pm 85$  pCi/L) (Figure 14). As noted in Section 2.3, available data indicate that Tc-99 and nitrate share similar transport characteristics and migration patterns in the East Fork Regime. In contrast to Tc-99 levels, however, nitrate concentrations have decreased over the past 10 years (Figure 7). Several factors may explain the divergent flux relationships suggested by the long-term concentration trends for Tc-99 (increasing) and nitrate (decreasing). For example, the divergent flux relationships may at least partially reflect the routine disposal of nitrate wastes at the former S-3 Ponds, which essentially emplaced a large contiguous mass of nitrate (from the Abandoned Nitric Acid Pipeline), as opposed to the intermittent disposal of Tc-99 wastes at the site, which emplaced more discontinuous “slugs” of Tc-99. Assuming that the decreasing nitrate concentrations in well GW-108 reflect reduced flux of nitrate resulting from the continued eastward (strike parallel) migration of the nitrate mass emplaced during routine operation of the S-3 Ponds, then the increasing Tc-99 concentrations may reflect a temporal “pulse” in flux of Tc-99 emplaced during intermittent disposal of Tc-99 wastes at the site (AJA 2000b).

Monitoring results for aquifer well GW-253 show increasing concentrations of PCE degradation products, notably 1,2-DCE (total) and vinyl chloride (Figure 15). This increasing trend is particularly evident for 1,2-DCE which increased from 60 µg/L in August 1989 to 250 µg/L in November 1999. However, the significance of these trends is not clear. For instance, if the increasing concentrations of 1,2-DCE and vinyl chloride reflect PCE/TCE degradation, then a concurrent decrease in the concentration of TCE (and PCE) would be expected. However, relatively stable trends are evident for the other VOCs detected in the groundwater samples from this well (PCE, TCE, carbon tetrachloride, and chloroform), which may reflect a steady flux of parent compounds from suspected DNAPL at the S-2 Site (DOE 1998).

Monitoring results for aquitard well GW-204 indicate increasing concentrations of elemental uranium and gross alpha activity (Figure 16). The total uranium concentration and gross alpha activity reported for the sample collected from the well in September 1999 (0.143 mg/L and 95 pCi/L) represent the second highest respective values ever reported for the well (the highest being 0.21 mg/L and 102 pCi/L in June 1993). As

noted in Section 3.1.2.3, uranium isotopes are the suspected source of the alpha radioactivity in the shallow groundwater at this well, and Building 9204-2 is the presumed source of the elemental and isotopic uranium (DOE 1998).

Monitoring results for aquitard well GW-782 show increasing concentrations of VOCs (Figure 17). As noted in Section 3.1.2.2, this well monitors a plume of dissolved VOCs containing a mixture of chloroethenes and chloroethanes, including parent compounds (PCE and 111TCA), intermediate degradation products (TCE, c12DCE, 11DCE, and 11DCA), and end degradation products (vinyl chloride and chloroethane). Concentrations of parent compounds and intermediate degradation products have increased slightly, whereas the concentrations of end degradation products have more clearly increased since the mid 1990s. For instance, vinyl chloride was detected in all five of the groundwater samples collected from the well between November 1996 (5 µg/L) and November 1998 (4 µg/L), but was detected in only three of the nine samples collected between June 1994 (1 µg/L) and May 1996 (not detected). Increasing concentrations of vinyl chloride and chloroethane suggest biotic degradation of PCE and 111TCA (and/or abiotic degradation of 111TCA).

Monitoring results for aquitard well GW-782 also show fluctuating but clearly increasing gross alpha activity in the groundwater at the well (Figure 17). As noted in Section 3.1.2.3, the overall lack of gross alpha activity in the shallower (GW-783) and deeper (GW-781) wells clustered with GW-782 indicate stratabound migration of alpha-emitting isotopes, particularly considering the upward vertical hydraulic gradients indicated by presampling groundwater elevations in these wells (Figure 17). Increasing gross alpha activity in the groundwater at well GW-782 indicates increased flux of radiological contaminants in the strike-parallel flowpaths intercepted by the well.

As noted in Section 3.1.3.2, the concentration of dissolved chloroethenes in shallow (< 25 ft bgs) aquitard wells GW-148 and GW-383, located north and northwest of New Hope Pond (Figure 6), show generally increasing long-term trends. Monitoring results for well GW-148 show that concentrations of 1,2-DCE were undetected through January 1990, first detected at an estimated value (i.e., less than the analytical reporting limit) of 3 µg/L in November 1994, and steadily increased to exceed 15 µg/L during CY 1999 (Figure 18). The monitoring results for well GW-383 show widely fluctuating but generally increasing concentrations of dissolved chloroethenes (Figure 18). Increasing concentrations of chloroethenes in the groundwater at these wells potentially reflect greater northeastward flux of dissolved VOCs toward the former channel of UEFPC from the DNAPL believed to be present in the subsurface near Building 9720-6 (DOE 1998).

Monitoring results for aquifer wells GW-151 and GW-220, which comprise a well cluster located east of the UEFPC distribution channel (Figure 6), show clearly increasing concentrations of dissolved chloromethanes and chloroethenes (Figure 19). Results for both wells show fairly steady concentration increases following the initial detection of VOCs in February 1986 (GW-151) and August 1988 (GW-220). The detection of these VOCs and the subsequent increasing concentration trends are believed to be a direct result of reduced recharge following closure of New Hope Pond, and the strong local hydrologic influence of the UEFPC distribution channel underdrain installed during construction of Lake Reality (DOE 1998).

Carbon tetrachloride results for aquifer well GW-153 show a fairly variable but moderately increasing long-term concentration trend (Figure 20). In general, carbon tetrachloride concentrations increased from less than 100 µg/L in the mid-1980s (e.g., 73 µg/L in January 1987) to about 150 µg/L in the early 1990s (e.g., 140 µg/L February 1990), remained below 200 µg/L through the mid 1990s (e.g., 180 µg/L in May 1995), then increased above 250 µg/L in the late 1990s (e.g., 260 µg/L in November 1999).

Monitoring results for aquifer well GW-223 show increasing concentrations of elemental uranium, gross alpha, and 1,2-DCE (Figure 21). The elemental uranium and gross alpha trends closely mirror each other and



show a generally decreasing trend before closure of New Hope Pond (and the associated Oil Skimmer Basin) but a clearly increasing trend following closure of New Hope Pond. For example, an order-of-magnitude increase in (total) uranium concentrations is evident between August 1989 (0.002 mg/L) and August 1999 (0.0236 mg/L). Dissolved chloroethenes in the well reflect somewhat divergent long-term trends, with results for (total) 1,2-DCE indicating an increasing trend, but results for PCE and TCE indicate a relatively steady (TCE) or slightly decreasing (PCE) trend (Figure 21). Contaminant concentration trends in well GW-223 generally coincide with a concurrent shift from upward vertical hydraulic gradients evident before closure of New Hope Pond to downward vertical hydraulic gradients evident after closure of New Hope Pond. As noted in Section 3.1.3.1, the increasing contaminant concentrations and the shift in the vertical hydraulic gradients are believed to be local effects related to closure of the former Oil Skimmer Basin. A shallow source near the wells is supported by the rapid increase in concentrations followed by a relatively slow decline at shallow well GW-154 (flushing) immediately after the site was closed (DOE 1998). The strong upward gradient present before 1989 inhibited downward contaminant migration, and the increasing contaminant trends at well GW-223 reflect the downward hydraulic gradient since 1989.



## 4.0 CONCLUSIONS AND RECOMMENDATIONS

The bulk of the monitoring results for the network of CY 1999 groundwater and surface water sampling locations are consistent with respective historical data regarding the types of contaminants detected, the concentrations of the contaminants, and the long-term contaminant concentration trends. A summary of significant findings based on evaluation of these CY 1999 results for the purposes of DOE Order 5400.1A is provided below.

### 4.1 Surveillance Monitoring

The CY 1999 monitoring results reported for 37 monitoring wells and five building sumps were evaluated for the purposes of Surveillance Monitoring in the East Fork Regime. Evaluation of the monitoring data for these wells shows the following new or significant findings.

- ° The CY 1999 monitoring results for aquitard well GW-109, which was last sampled in June 1995, show that: (1) contaminant concentrations within the plume emplaced during operation of the former S-3 Ponds, particularly nitrate ( $>9,000$  mg/L) and beta radioactivity ( $>10,000$  pCi/L), remain very high at depth ( $>100$  ft bgs) in the Nolichucky Shale near the Y-12 Plant Salvage Yard; (2) VOC concentrations in the deeper groundwater at well GW-109 are substantially higher than evident in the shallower groundwater at well GW-108; (3) a clearly decreasing long-term gross beta trend is evident in the deeper groundwater at well GW-109 whereas an increasing long-term gross beta trend is evident in the shallow groundwater at well GW-108; and (4) an upward vertical hydraulic gradient may promote contaminant migration from GW-109 toward GW-108.
- ° Several of the S-3 Ponds “signature” contaminants were detected in the samples collected during CY 1999 from sump 9202-4ELSU, which is in the elevator shaft of a process building located more than 3,000 ft east of the former S-3 Ponds. These monitoring results show that the concentrations of the more mobile contaminants in the sump (e.g., nitrate and Tc-99) have increased or remained fairly unchanged since the mid-1990s, whereas the concentration of the less mobile contaminants (e.g., mercury and uranium) have decreased substantially over this period.
- ° The CY 1999 monitoring results for aquitard well GW-337, which was last sampled in May 1995, show that the summed concentration of the dissolved VOCs in the shallow groundwater near the WCPA remain above  $8,000$   $\mu\text{g/L}$ . These results also continue the generally decreasing long-term concentration trend indicated by historical data for well GW-337.
- ° The CY 1999 monitoring results for groundwater samples collected from aquifer well GW-253, which was last sampled in June 1996, show that this well continues to yield moderately acidic (field pH 4.8 - 5.3) calcium-magnesium-bicarbonate groundwater characterized by high concentrations of nitrate (788 - 952 mg/L), chloride (123 - 137 mg/L), copper (36.2 - 39.3 mg/L), cadmium (3.27 - 3.45 mg/L), manganese (49.3 - 54.3 mg/L), nickel (1.78 - 2.01 mg/L), and zinc (4.94 - 6.25 mg/L). These results also reflect an increasing long-term concentration trend for selected VOCs detected in the groundwater at this well.
- ° Elevated concentrations of nickel and/or chromium reported for the groundwater samples collected during CY 1999 from several wells in the central (GW-776, GW-783, and GW-792) and eastern (GW-380) plant areas potentially reflect MIC of the stainless steel well casing and screen rather than migration from potential contaminant source areas. This interpretation is supported by preliminary data obtained in May 2000, which indicate that groundwater in wells GW-783 and GW-380 contains

a complex bacterial consortium that includes iron-related, slime-forming, and sulfate-reducing organisms.

- ° The CY 1999 monitoring results for aquitard well GW-204 (located near Building 9204-4 in the central plant area), which was last sampled in November 1993, show that total uranium concentrations in the shallow groundwater at this well exceed the proposed federal MCL (0.02 mg/L) and reflect a generally increasing long-term concentration trend that coincides with a corresponding increase in alpha radioactivity in the well.
- ° Uranium results obtained during CY 1999 are consistent with respective historical data for wells GW-154 and GW-223, which were last sampled in November 1996, and show that uranium levels in each well remain above the proposed MCL (0.02 mg/L). Moreover, these results also illustrate the substantial change in uranium concentration that occurred after closure of New Hope Pond in 1988, with a strongly decreasing concentration trend in well GW-154 and a strongly increasing concentration trend in well GW-223. Conversely, the CY 1999 VOC show decreasing long-term concentration trends in this well (VOCs were not detected in well GW-154).
- ° Sampling results obtained during CY 1999 show that well GW-832 yields (sulfate-enriched) calcium-magnesium bicarbonate groundwater containing fairly moderate concentrations of carbon tetrachloride along with very low levels of chloroform and PCE, although the carbon tetrachloride and PCE levels remain above respective MCLs. Historic data show relatively stable VOC concentration trends since the well was installed in CY 1996. Well GW-832 is completed in the gravel underdrain of the UEFPC distribution channel.

#### **4.2 Exit Pathway/Perimeter Monitoring**

The CY 1999 monitoring results reported for nine surface water sampling locations and 12 monitoring wells in the East Fork Regime were evaluated for the Exit Pathway/Perimeter Monitoring purposes of DOE Order 5400.1A. Contaminants originating from sources within the Y-12 Plant were detected in samples collected during CY 1999 from four of the monitoring wells (GW-151, GW-220, GW-722, and GW-733) and all of the surface water locations (OF 195, OF 221, OF 225, OF 200, OF 51, Station 8, SP-17, LRSPW, and Station 17). Results for these sampling locations are consistent with respective historical data (where available) and show:

- ° Dissolved chloroethene and chloromethane concentrations in the groundwater at paired wells GW-151 and GW-220 continue to show a long-term increasing trend, which reflects the influence of the UEFPC distribution channel underdrain.
- ° Dissolved chloromethane concentrations in the groundwater collected from several of the sampling ports at depths from about 300 to 450 ft bgs in well GW-722 remain above 500 µg/L.
- ° According to the manufacturer, the Westbay™ sampling system in well GW-722 contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (e.g., port 26).
- ° Dissolved chloromethane concentrations in well GW-733 have generally decreased over the past several years but nonetheless reflect continued strike-parallel migration in the Maynardville Limestone toward Union Valley east of the ORR property boundary.

- ° Nitrate concentrations were highest ( $> 9.5$  mg/L) in surface water samples collected in the western plant area east of the S-3 Site (OF 195, OF 221, and OF 225) and in samples from spring SP-17, located downgradient from a former stockpile of urea used to remove ice from roadways.
- ° Total uranium concentrations exceeded the proposed MCL in six surface water stations: three storm drain outfalls in the western plant area (OF 195, OF 221, and OF 225) and three location in UEFPC (OF 200, Station 8, and Station 17). The uranium concentrations varied by more than an order of magnitude for all of these locations and the highest concentrations were reported during generally higher flow in April (OF 195, OF 221, and OF 225) or immediately following a storm event in July (OF 200, Station 8, and Station 17).
- ° Five of the surface water sampling locations (OF 200, Station 8, OF 51, LRSPW, and Station 17) had samples that contained dissolved VOCs, primarily chloroethenes (PCE, TCE, and c12DCE) and chloromethanes (carbon tetrachloride and chloroform).

### 4.3 Contaminant Concentration Trends

Increasing long-term contaminant concentration trends are indicated by the monitoring data for 10 of the CY 1999 sampling locations in the East Fork Regime, including two wells in the western plant area (GW-108 and GW-253), two wells in the central plant area (GW-204 and GW-782), and six wells (GW-148, GW-151, GW-153, GW-220, GW-223, and GW-383) in the eastern plant area. For the most part, the increasing contaminant concentrations reflect the hydrochemical dynamics within the groundwater contaminant plumes. Monitoring results for the remaining CY 1999 sampling locations generally continue the decreasing or indeterminant concentration trends (Table B.4) evident since the late 1980s and early 1990s. These trends probably reflect a combination of several factors, including compliance with waste management regulations, waste minimization and source control measures, remedial actions, natural attenuation mechanisms, and, in some cases, changes in sampling procedures and analytical methods.

### 4.4 Recommendations

Based on evaluation of the CY 1999 groundwater and surface water monitoring data, the following actions are recommended:

- ° Discontinue collection of filtered samples for metals analyses from Westbay wells, surface water stations, and spring locations. Samples from these locations typically have low suspended solids concentration. Unfiltered samples with higher suspended solids normally have higher concentrations of trace metals commonly found in uncontaminated sediment (e.g., aluminum and iron). Additionally, comparison of filtered to unfiltered results has little effect on data evaluation. Based on monitoring results obtained during CY 1999 for surface water and spring samples in the Bear Creek Hydrogeologic Regime, unfiltered sample results are sufficient for data evaluation purposes.
- ° Collect groundwater samples from Westbay well GW-722 only from the five zones in the primary contaminant flow pathway: ports 10, 14, 17, 20, and 22. Results for the other zones have consistently shown a lack of primary contaminants and additional annual monitoring data are not needed.

- ° Add sampling locations at selected building sumps (e.g., Building 9204-1) that intercept contaminated (e.g., nitrate, Tc-99, VOCs) groundwater east of the S-3 Site as part of DOE Order 5400.1A site surveillance monitoring.
- ° Analysis for Tc-99 activity should be performed on samples from selected locations downgradient of the S-3 Site. Because sample preparation for gross beta analysis tends to volatilize Tc-99, a separate analysis for Tc-99 activity is preferred.

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## **APPENDIX A**

### **FIGURES**

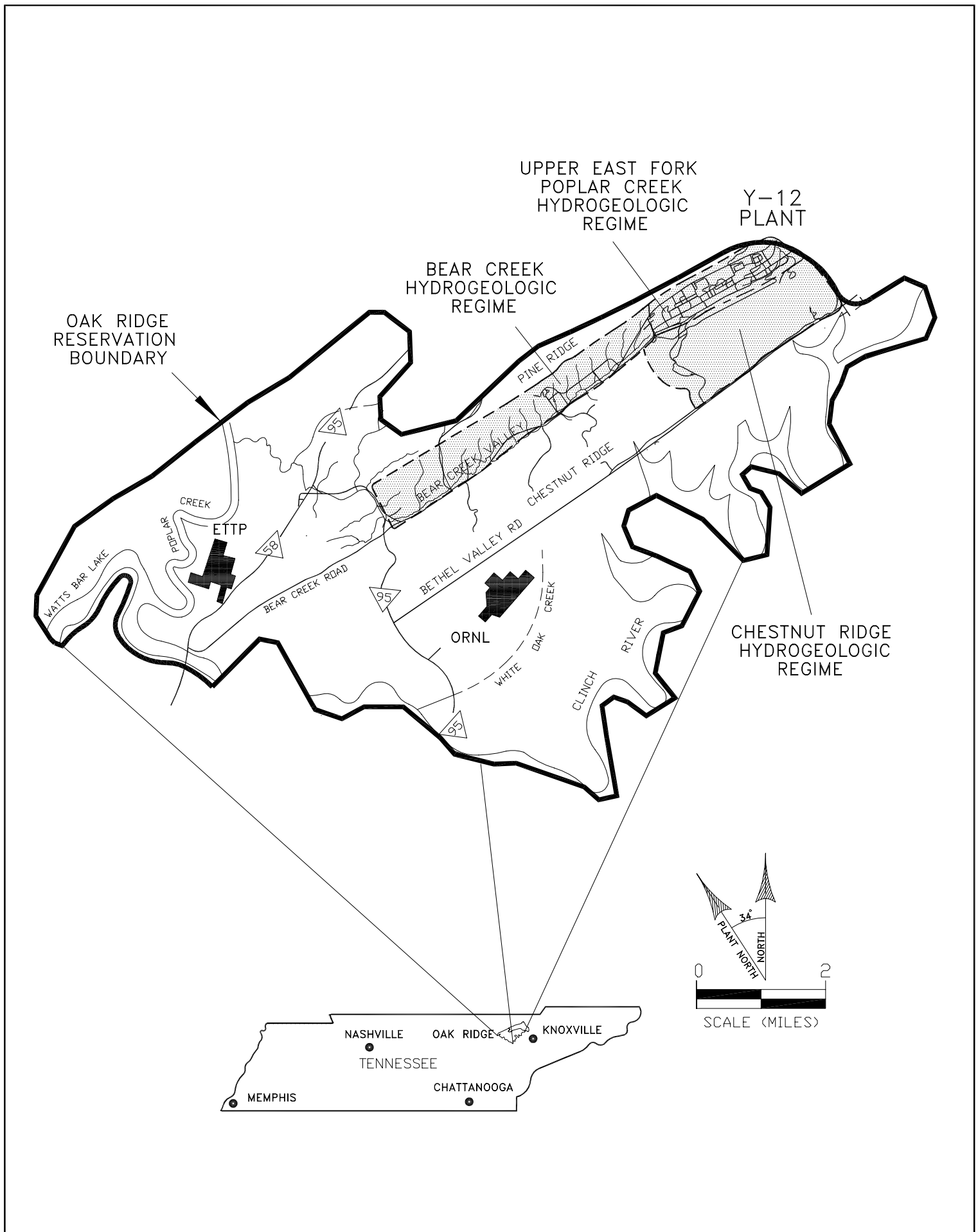
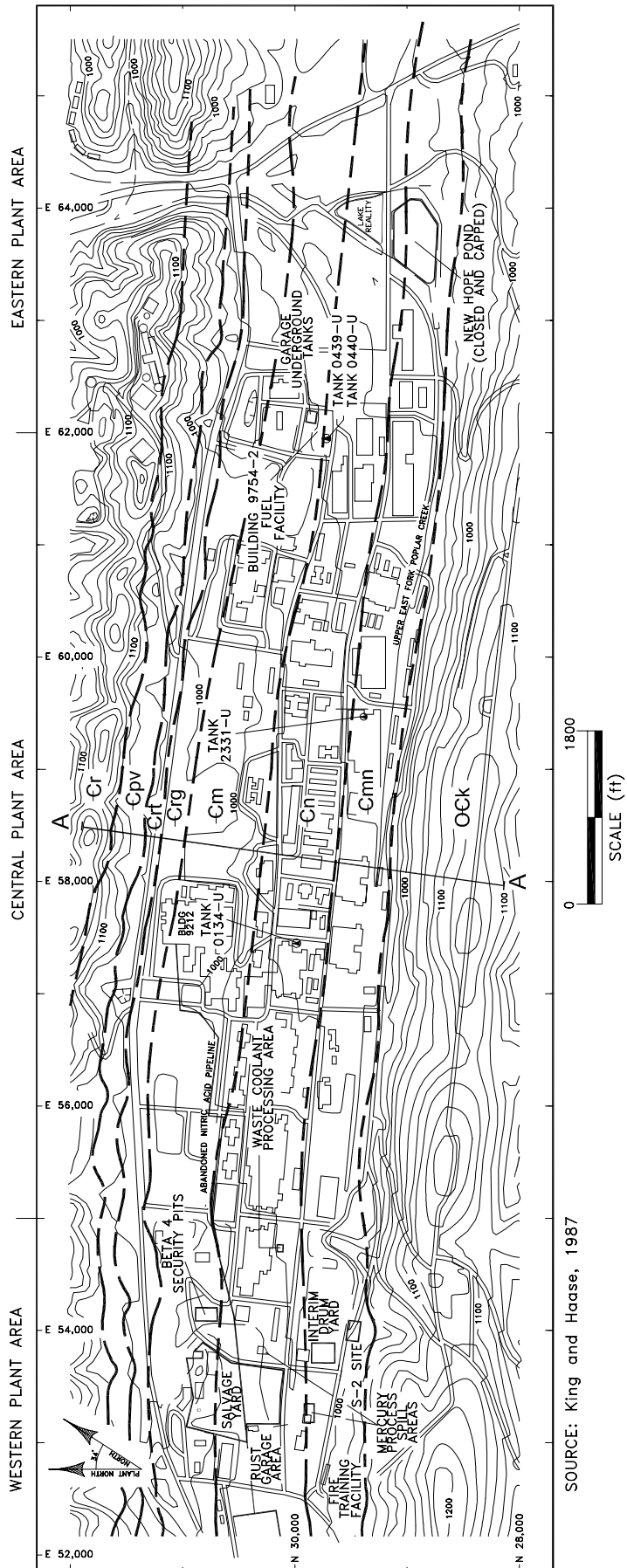
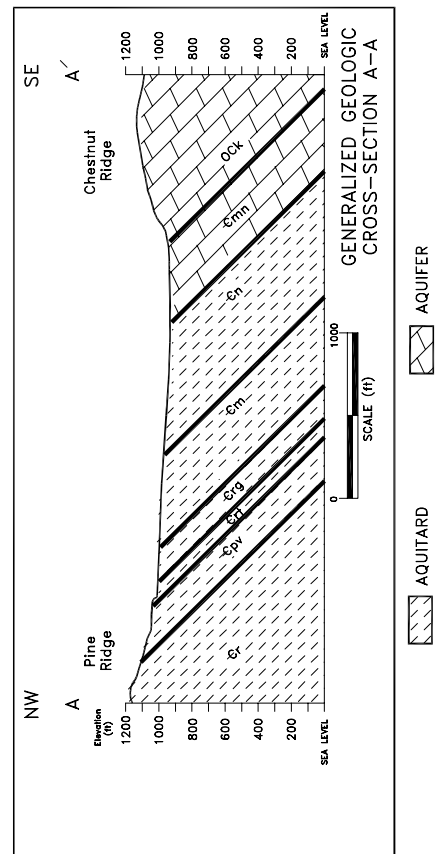


Fig. 1. Hydrogeologic regimes at the Y-12 Plant.

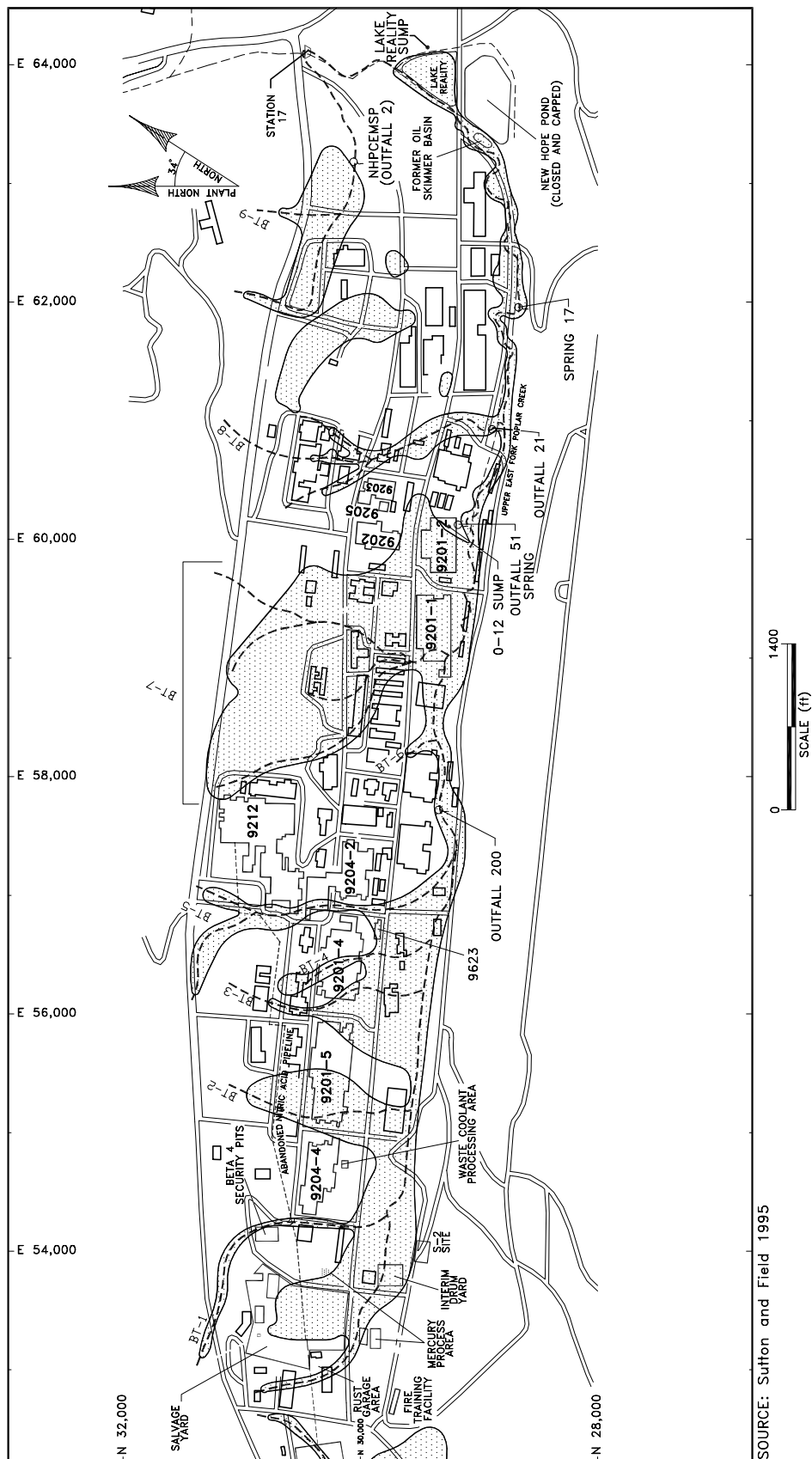


SOURCE: King and Haase, 1987



SYSTEM	GROUP	HYDRO UNIT	FORMATION	MAP SYMBOL	THICKNESS (ft)
CAMBRIAN	UPPER	KNOX	COPPER RIDGE DOLOMITE	Ock	NOT DETERMINED
			MAYNARDVILLE LIMESTONE	Cmn	418-450
	MIDDLE	CONASAUGA	NOLICHUCKY SHALE	Cn	422-550
			MARYVILLE LIMESTONE	Cm	346-445
			ROGERSVILLE SHALE	Crg	90-120
			RUTLEDGE LIMESTONE	Crt	90-120
			PUMPKIN VALLEY SHALE	Cpv	260-320
LOWER		ROME FORMATION	Cr	NOT DETERMINED	


Fig. 2. Topography and bedrock geology in the Upper East Fork Poplar Creek Hydrogeologic Regime.



SOURCE: Sutton and Field 1995

#### EXPLANATION

 - FILL THICKNESS GREATER THAN  
OR EQUAL TO 5 FT

 - BURIED TRIBUTARY (BT-)


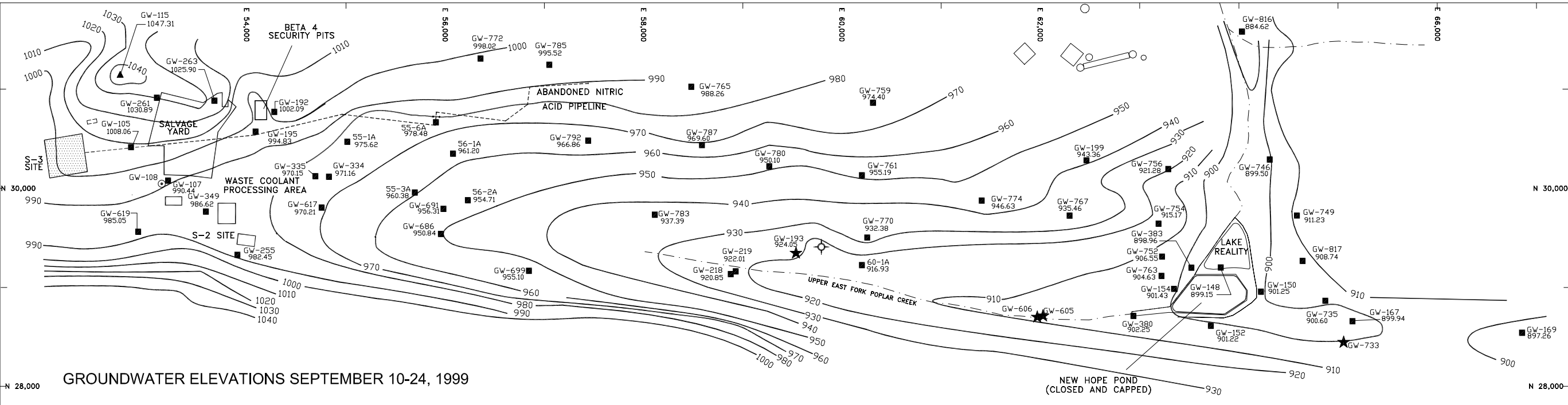
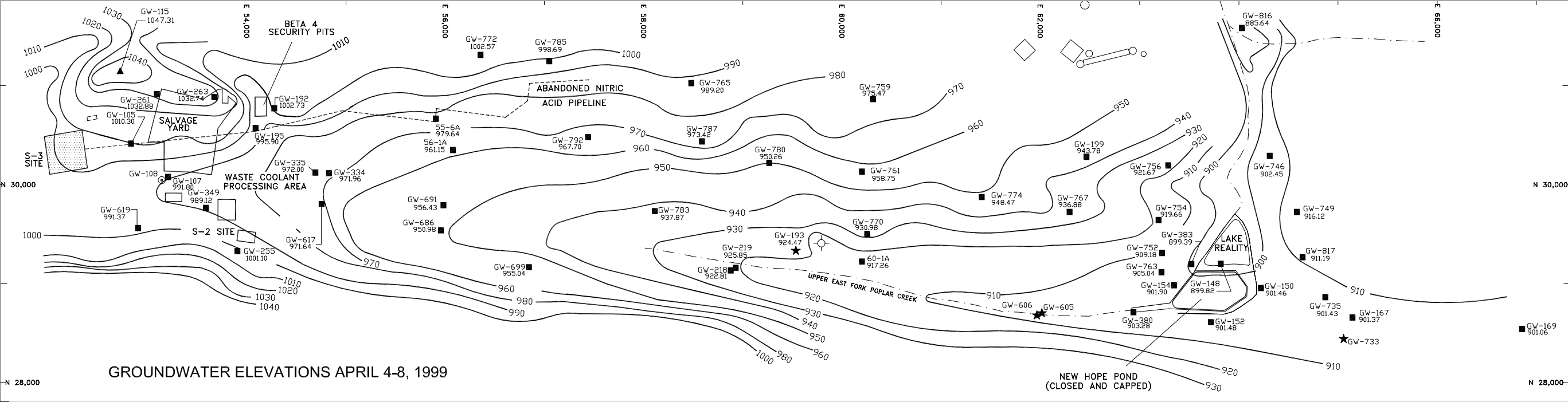
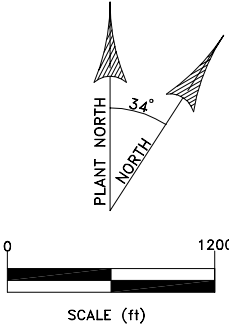
 - SPRING

Fig. 3. Fill areas in the Y-12 Plant and preconstruction drainage features.



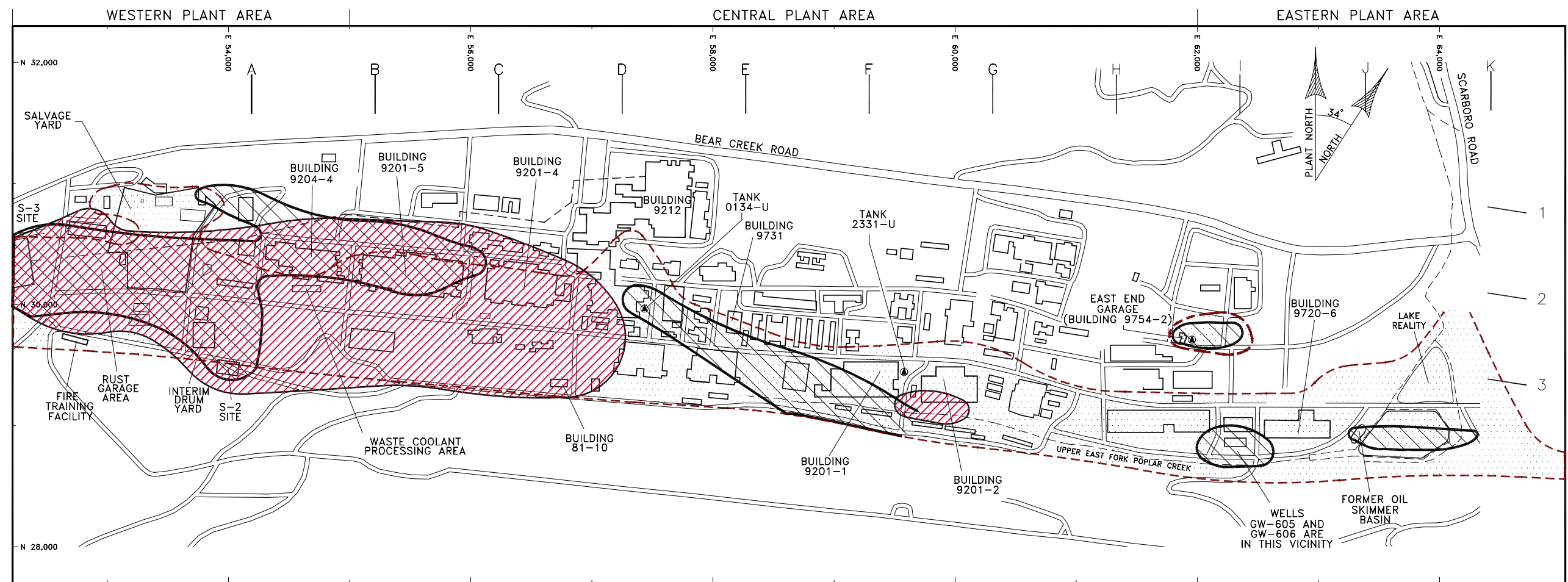
EXPLANATION



- — WATER TABLE INTERVAL MONITORING WELL
- ▲ — RCRA BACKGROUND/UPGRADIENT MONITORING WELL
- ⊙ — RCRA POINT-OF-COMPLIANCE MONITORING WELL
- ★ — RCRA PLUME DELINEATION MONITORING WELL

- 980 — APPROXIMATE WATER-LEVEL ISOPLETH (ft msl)
- - - SURFACE DRAINAGE FEATURE
- ⊙ — BUILDING 9201-2 SUMP

Fig. 4. Seasonal groundwater elevations in the Upper East Fork Poplar Creek Hydrogeologic Regime, 1999.



NOTE: MODIFIED FROM U.S. DEPARTMENT OF ENERGY 1998

0 1000  
SCALE (ft)

### EXPLANATION

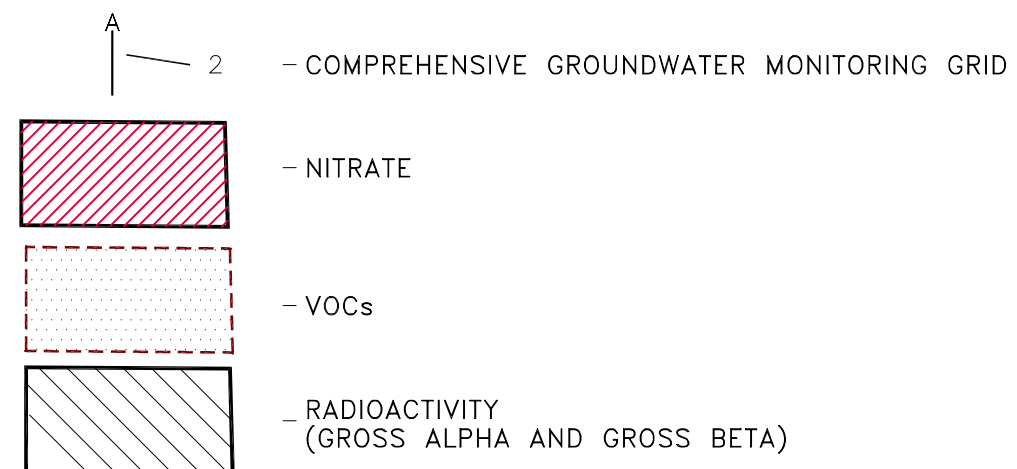
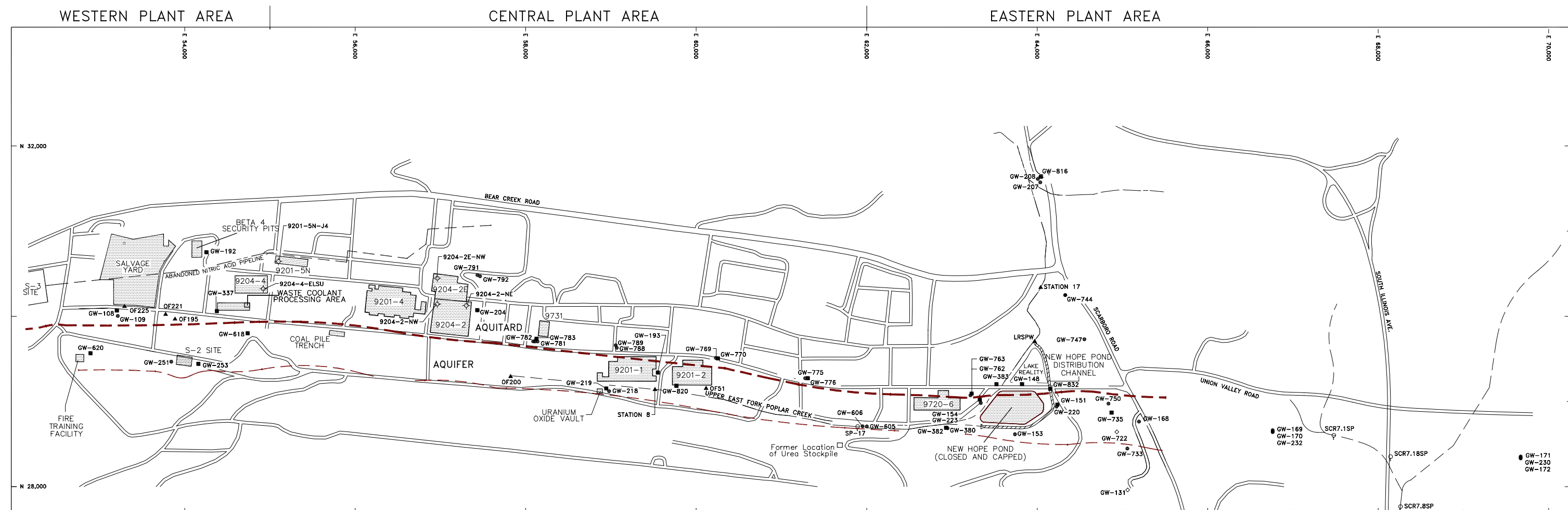
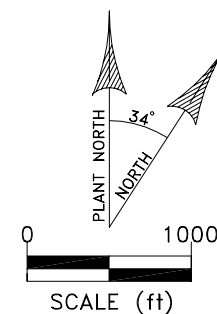


Fig.5. Source areas and generalized extent of groundwater contamination in the Upper East Fork Poplar Creek Hydrogeologic Regime.



# EXPLANATION

- — Water Table Monitoring Well
  - — Bedrock Monitoring Well
  - ◇ — Well With Westbay Multiport Sampling System (Discrete Vertical Sampling zones, see Figures 8 and 9)
  - ◊ — Spring Sampling Location
  - ▲ — Surface Water Sampling Location
  - ◊ — Sump Sampling Location
  - LRSPW — Lake Reality Emergency Spillway
- |          |  |
|----------|--|
| AQUITARD | <ul style="list-style-type: none"> <li>— NOLICHUCKY SHALE</li> <li>— MARYVILLE LIMESTONE</li> <li>— ROGERSVILLE SHALE</li> <li>— RUTLEDGE LIMESTONE</li> <li>— PUMPKIN VALLEY SHALE</li> <li>— ROME FORMATION</li> </ul> |
| AQUIFER  | <ul style="list-style-type: none"> <li>— COPPER RIDGE DOLOMITE</li> <li>— MAYNARDVILLE LIMESTONE</li> </ul>  |





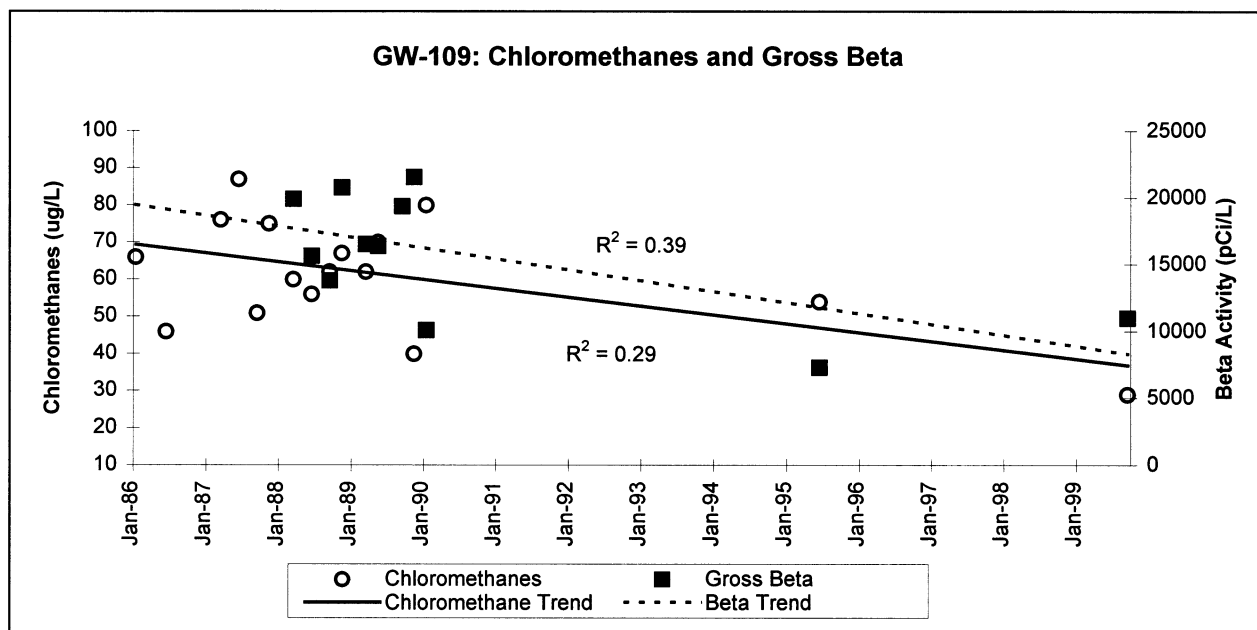
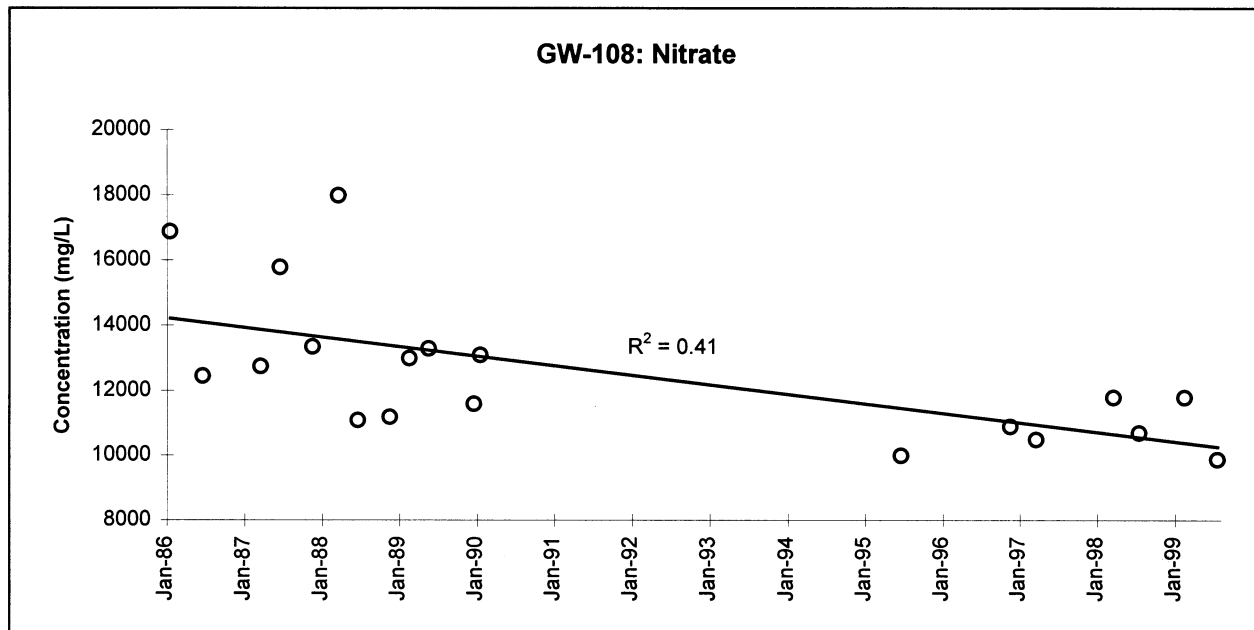
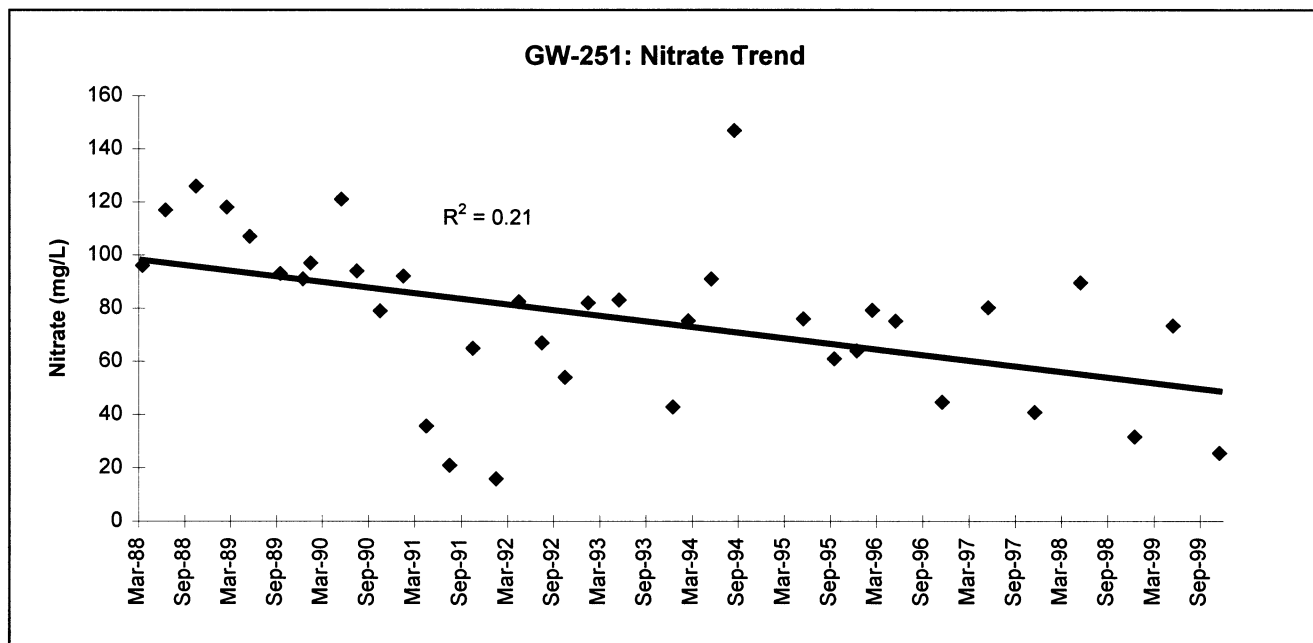
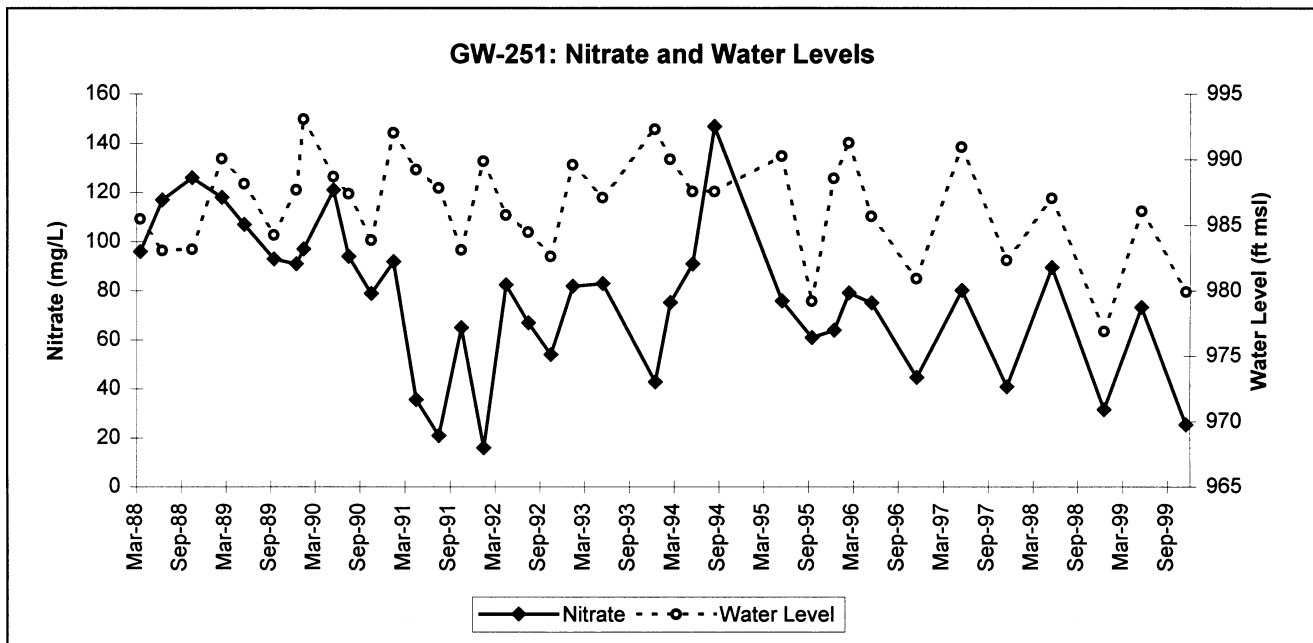
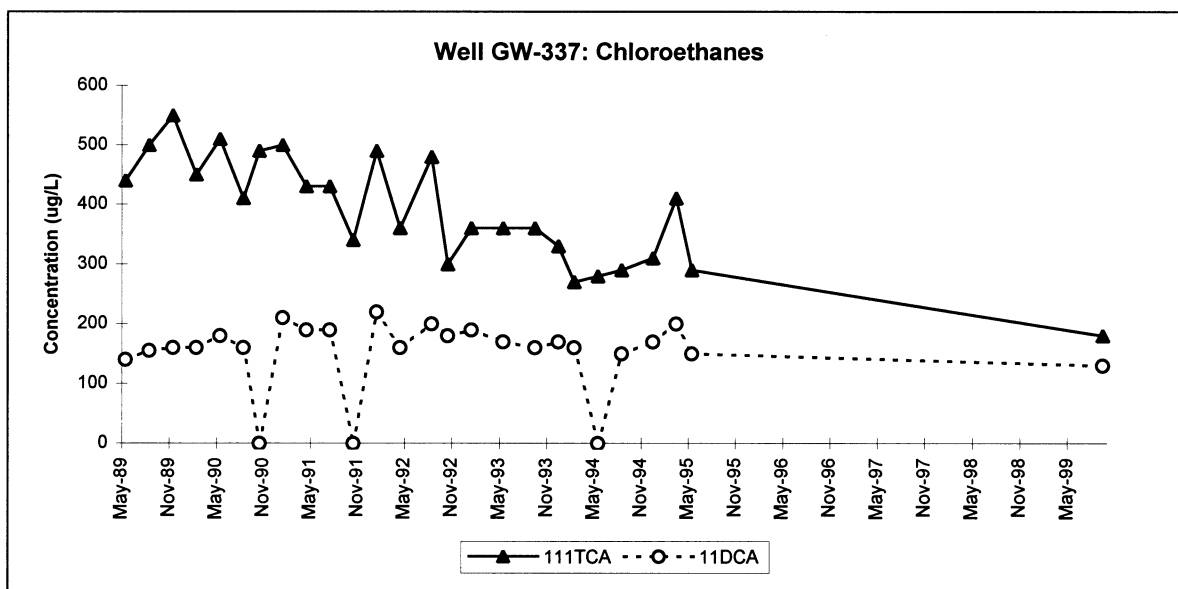
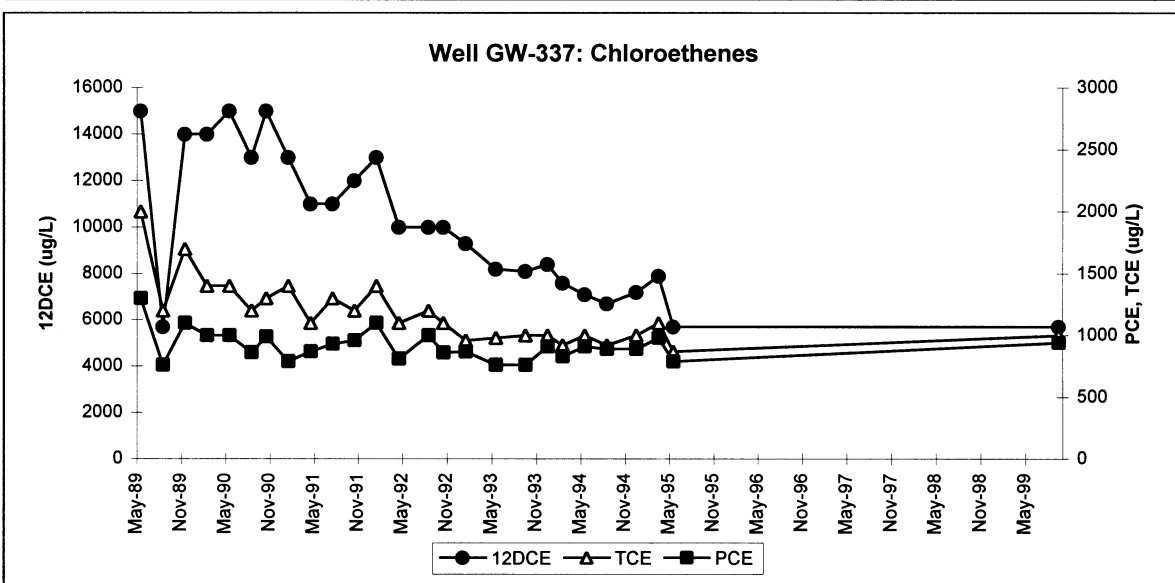
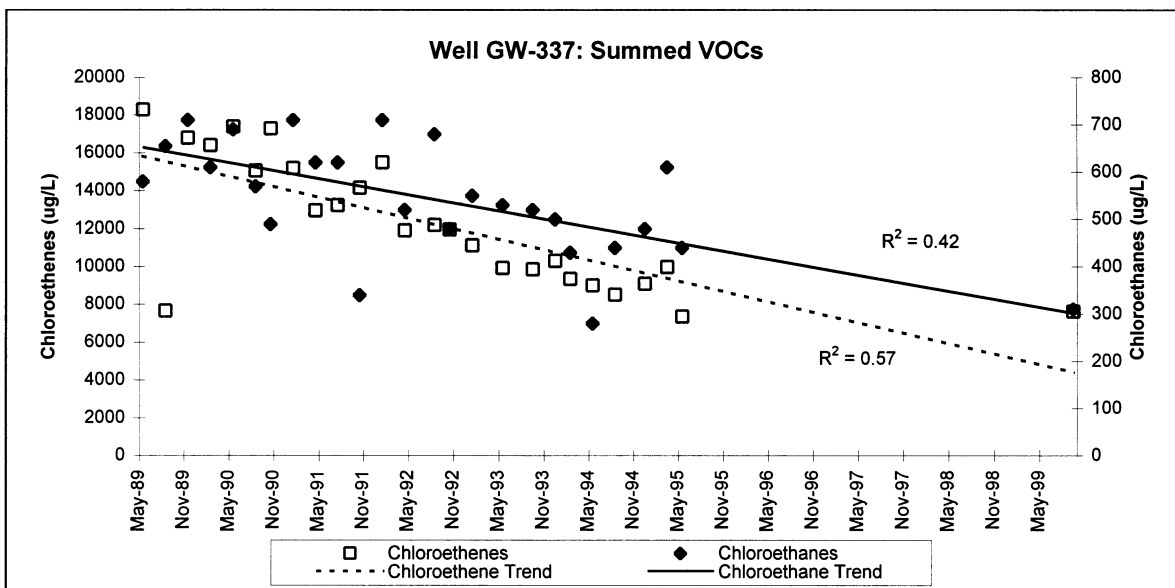


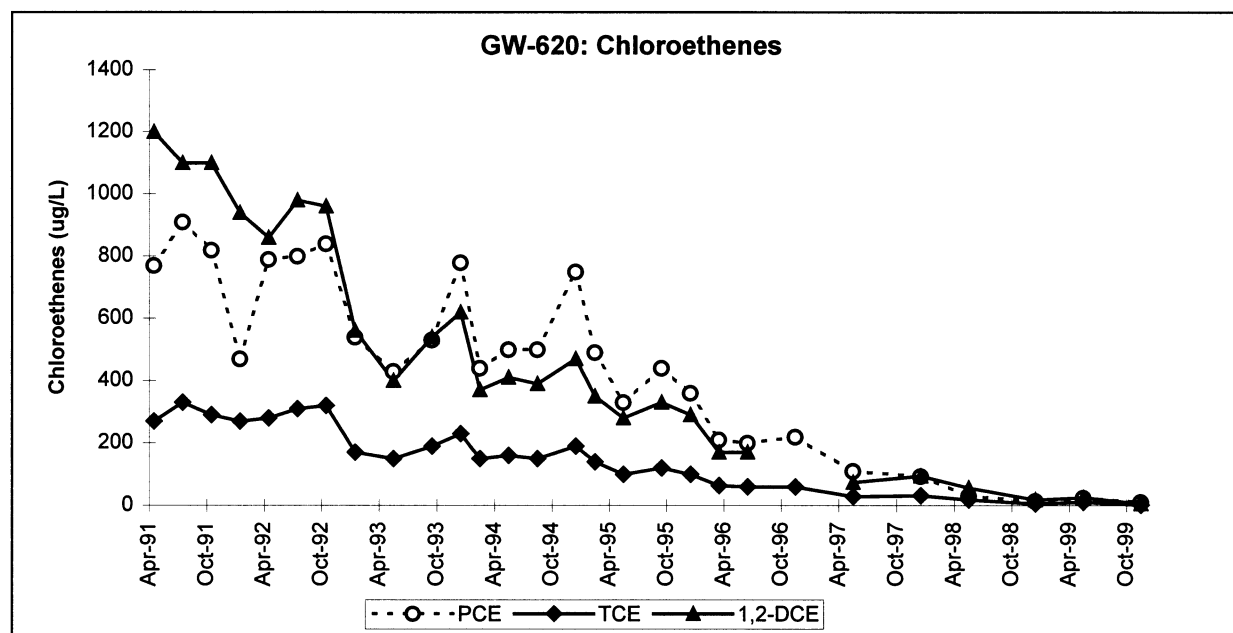
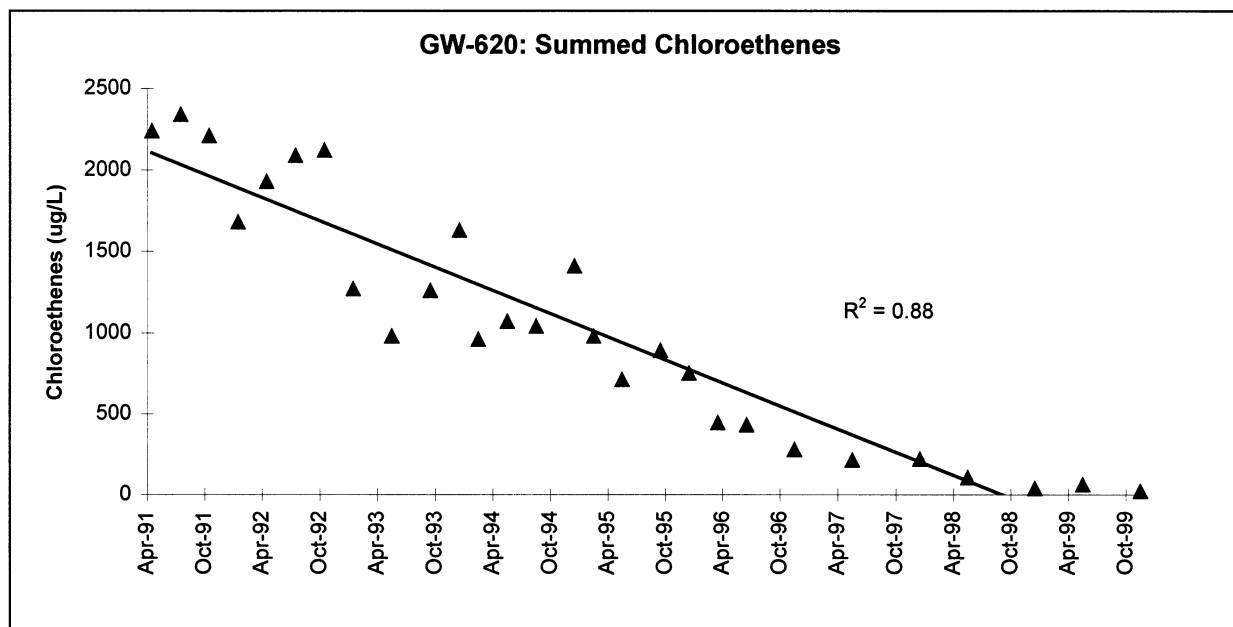
Fig. 7. Decreasing contaminant concentrations in wells GW-108 and GW-109.



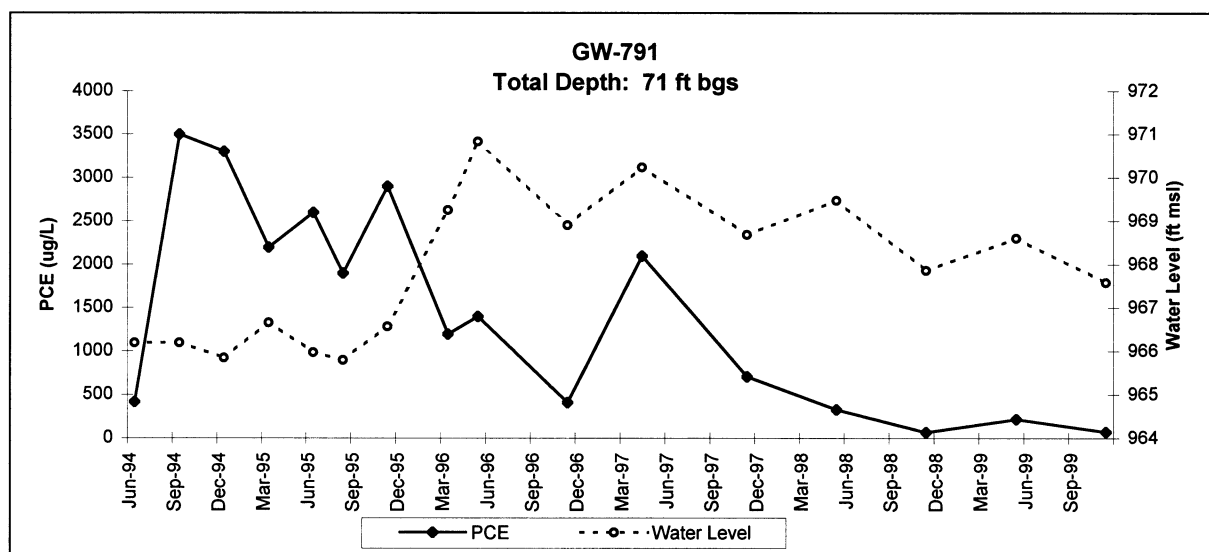
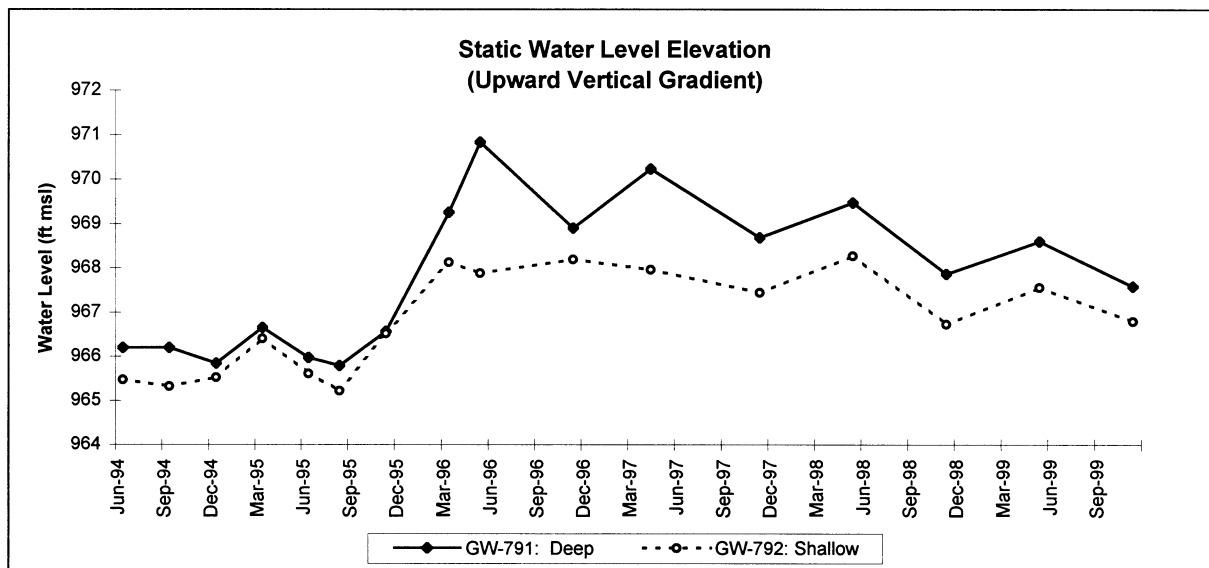
**Fig. 8. Presampling water levels and decreasing nitrate concentrations in well GW-251.**



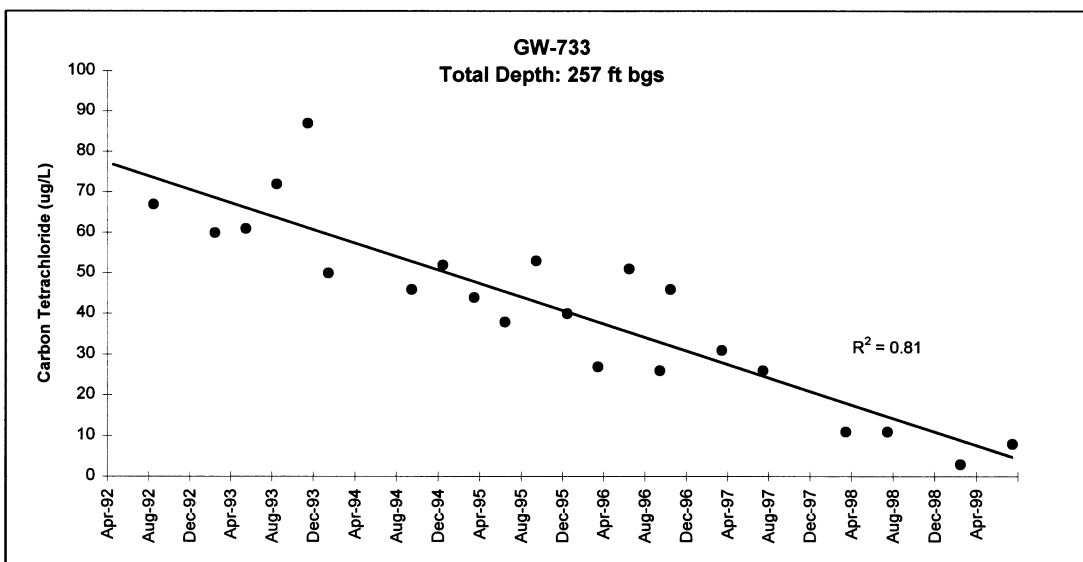
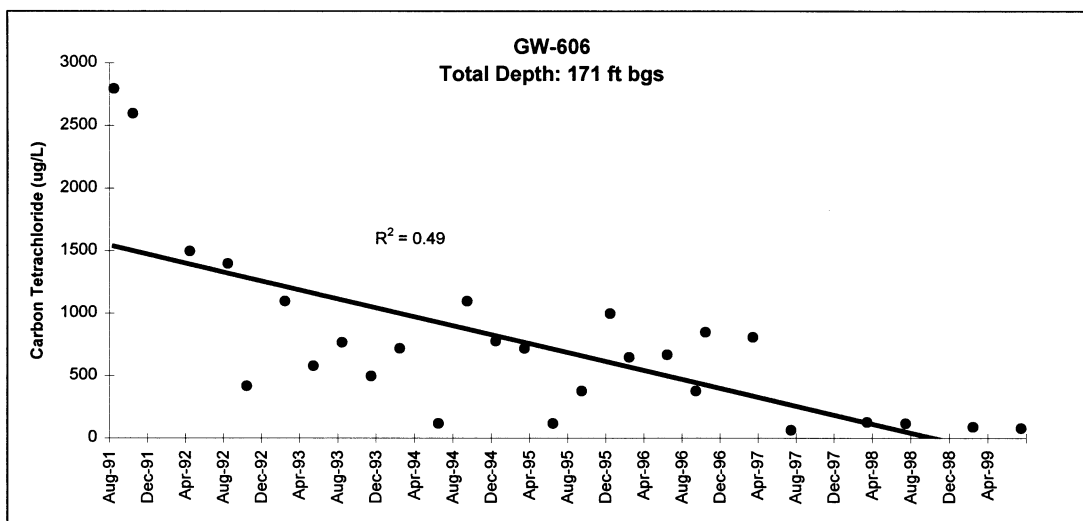
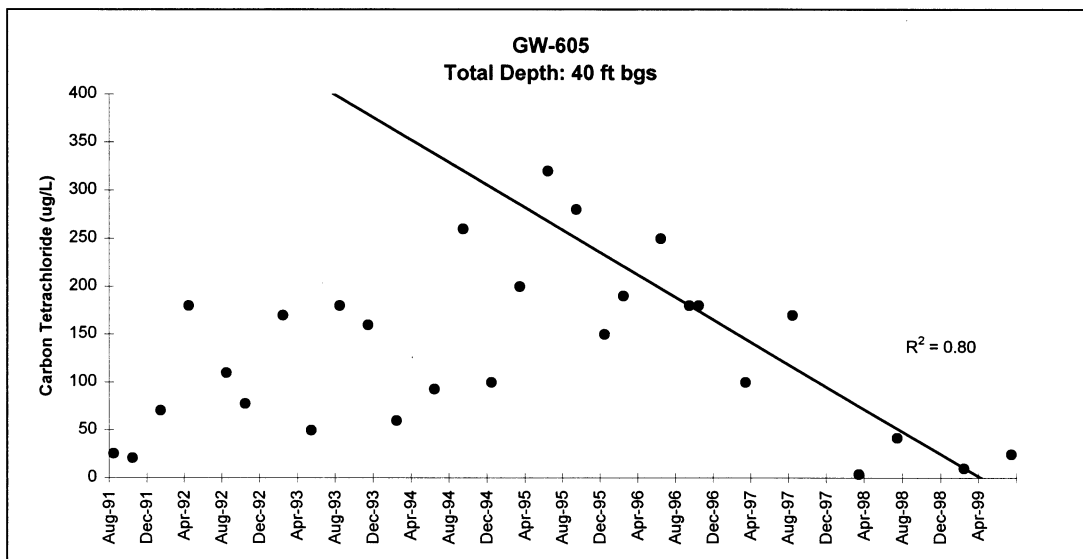
**Fig. 9. Decreasing VOC concentrations in well GW-337.**



**Fig. 10. Decreasing VOC concentrations in well GW-620.**



**Fig. 11. Presampling water levels and decreasing PCE concentrations in well GW-791.**  
A-11



**Fig. 12. Decreasing carbon tetrachloride concentrations in wells GW-605, GW-606, and GW-733.**

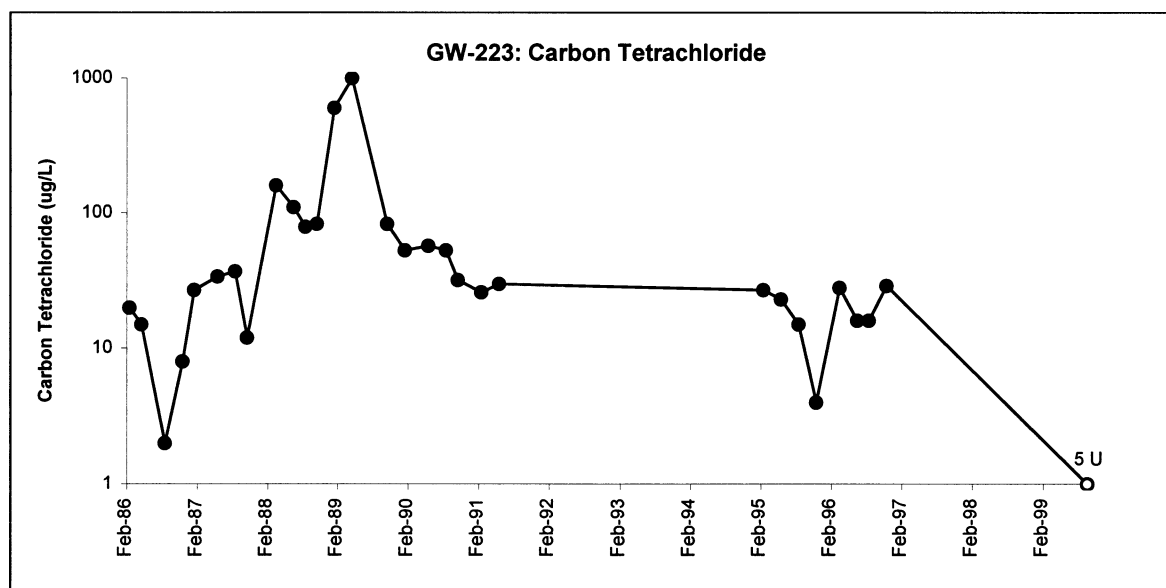
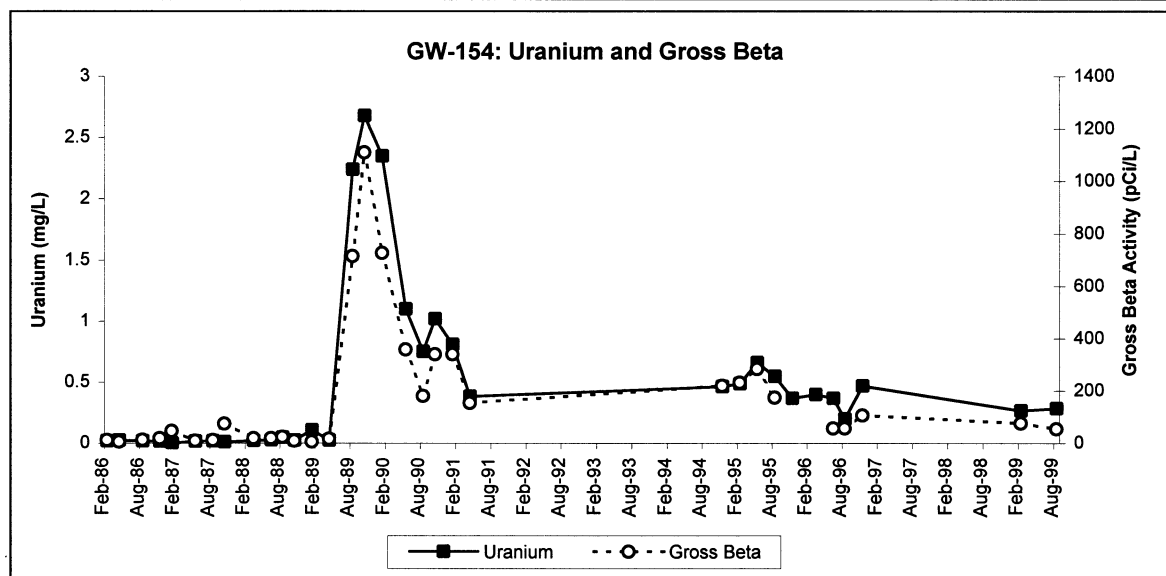
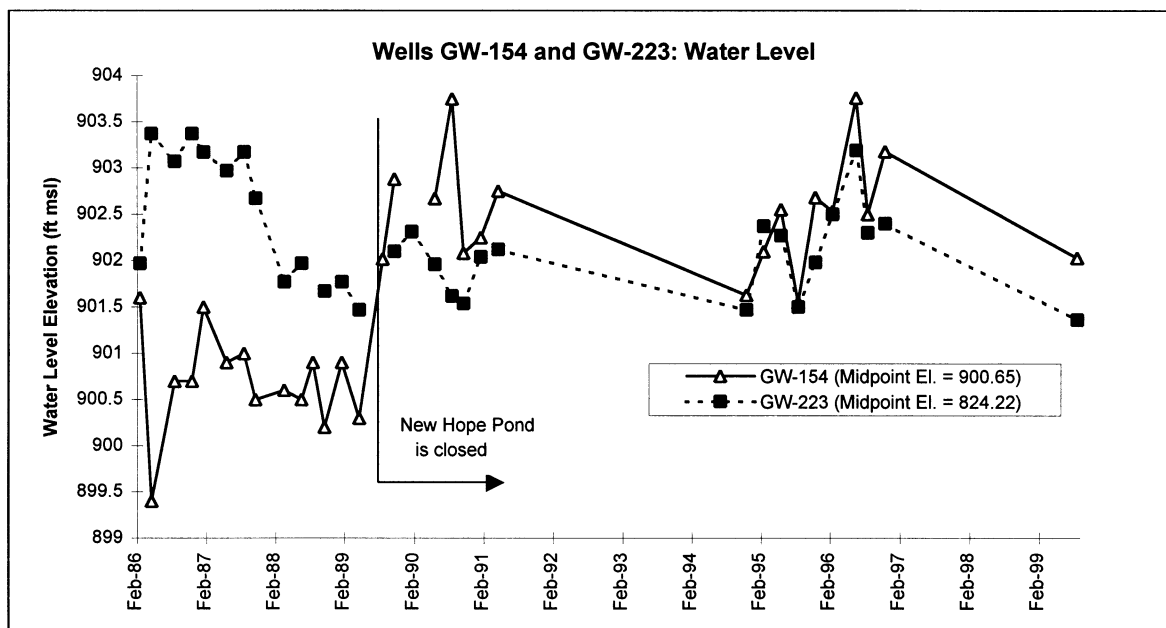
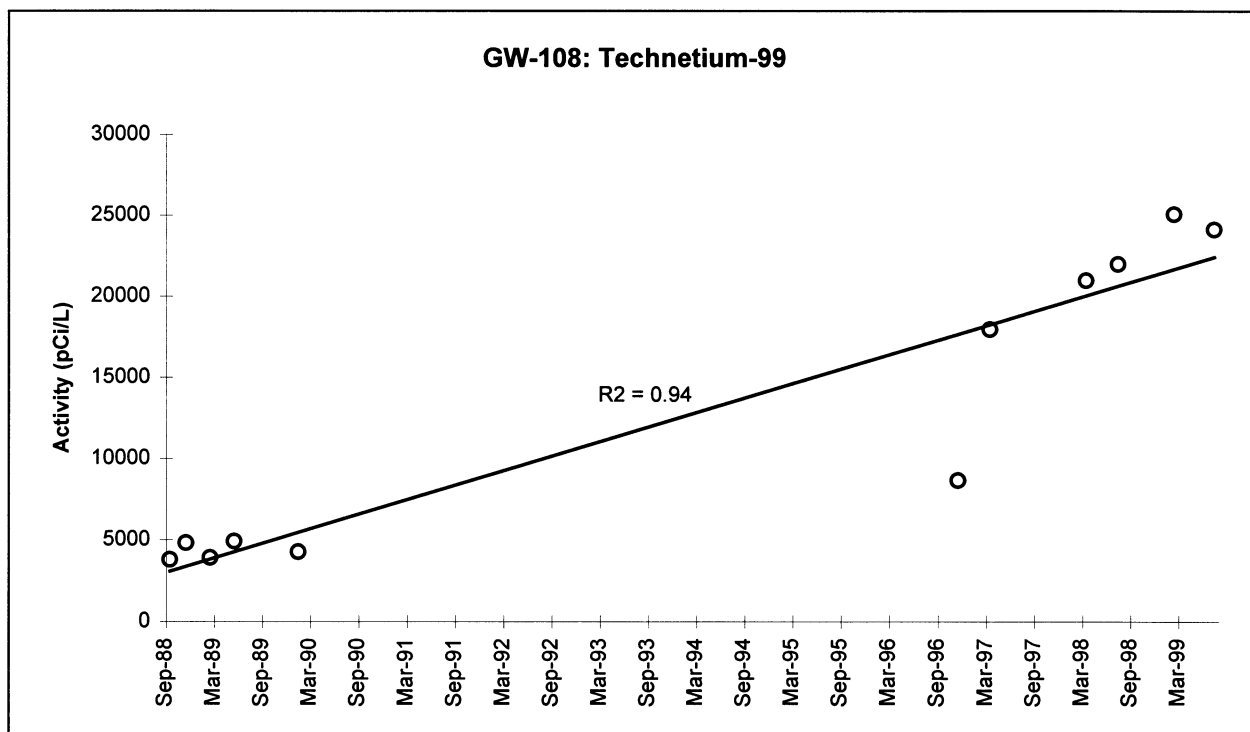
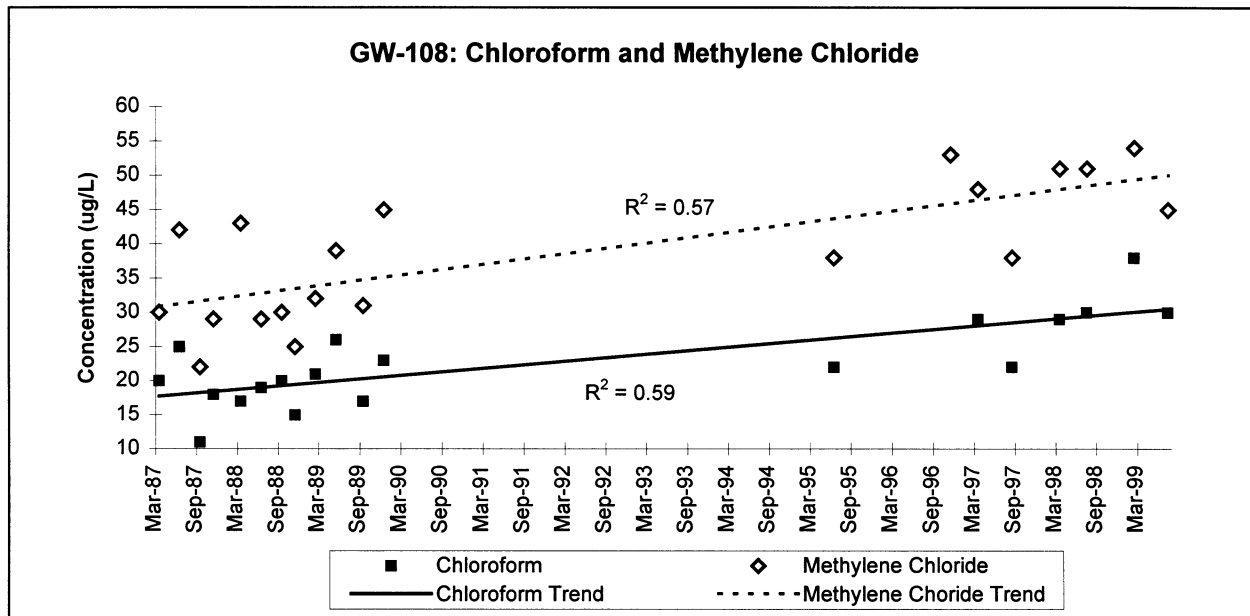
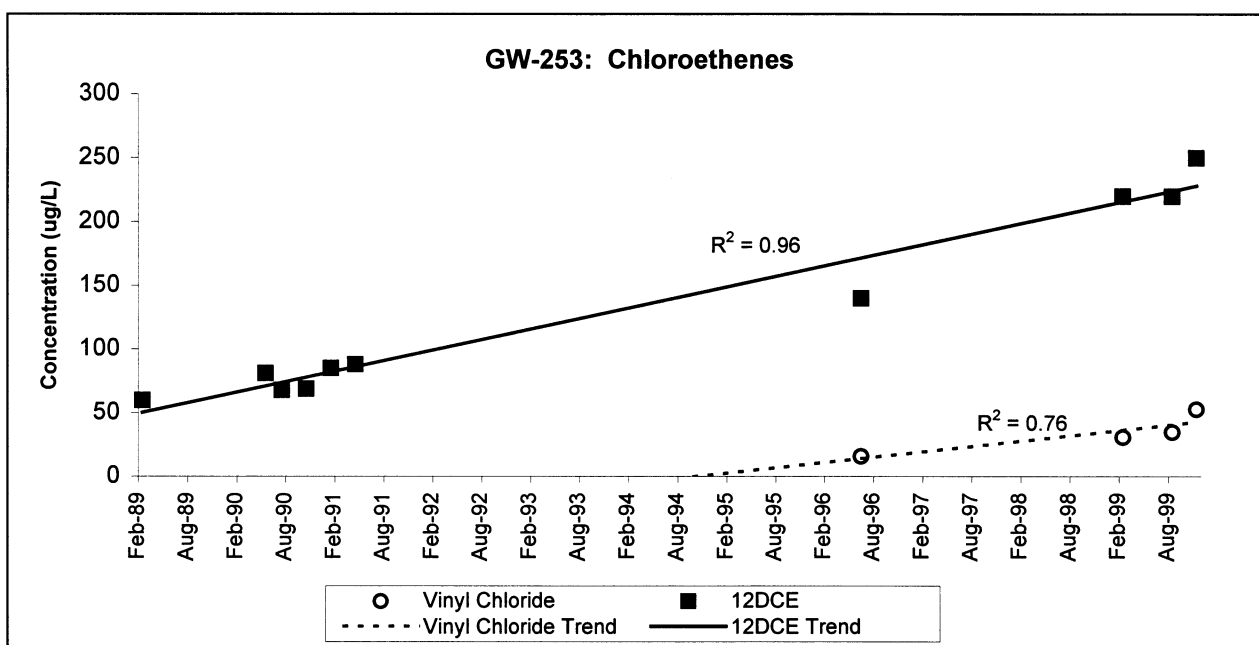


Fig. 13. Presampling water levels and decreasing contaminant concentrations in wells GW-154 and GW-223.

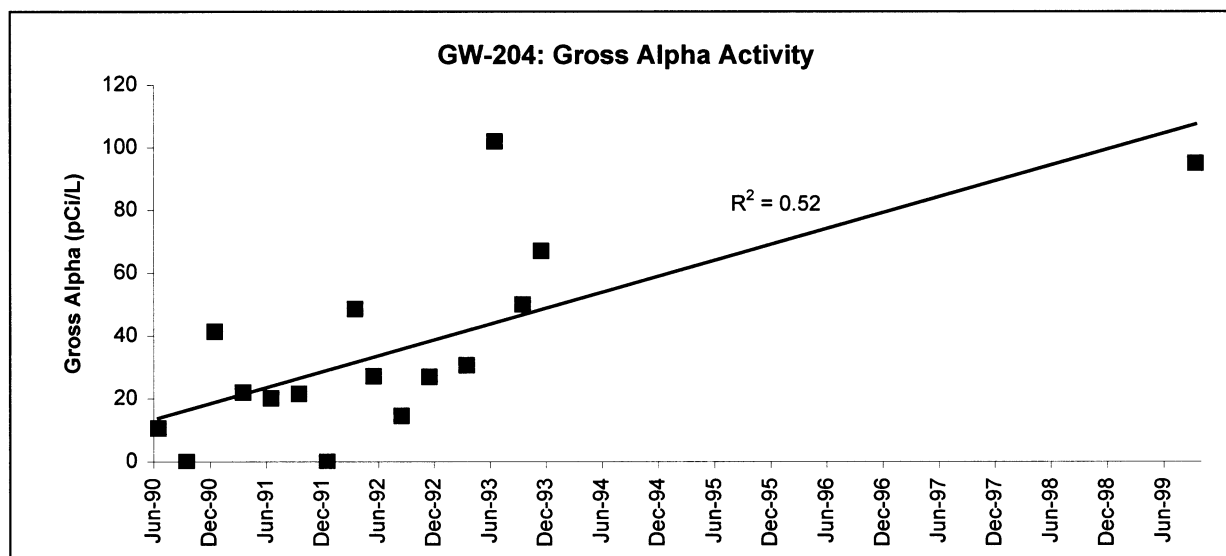
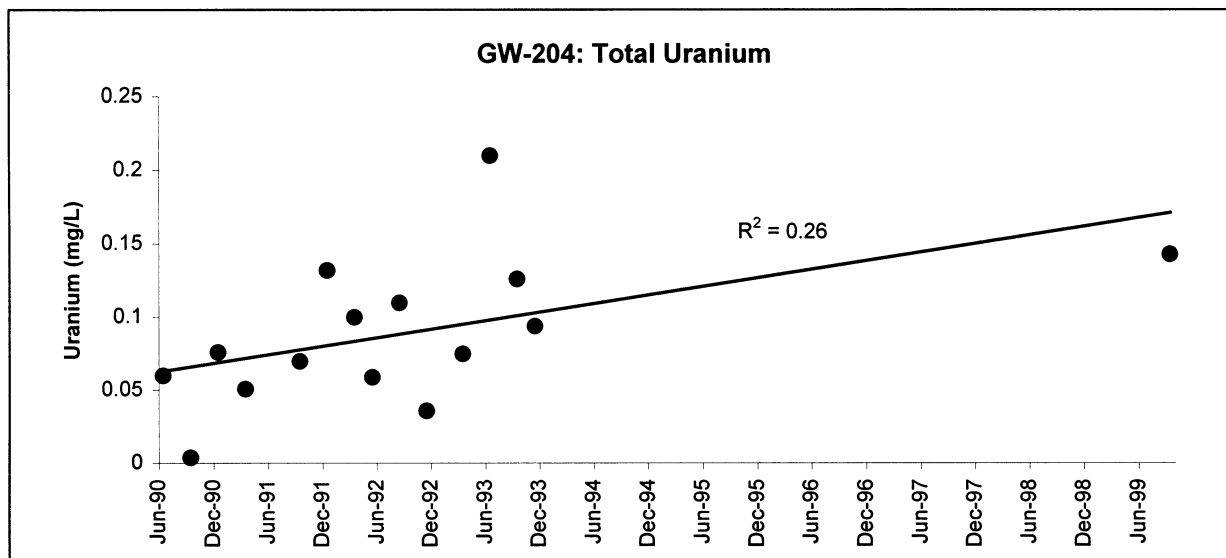


**Fig. 14. Increasing contaminant concentrations in well GW-108.**

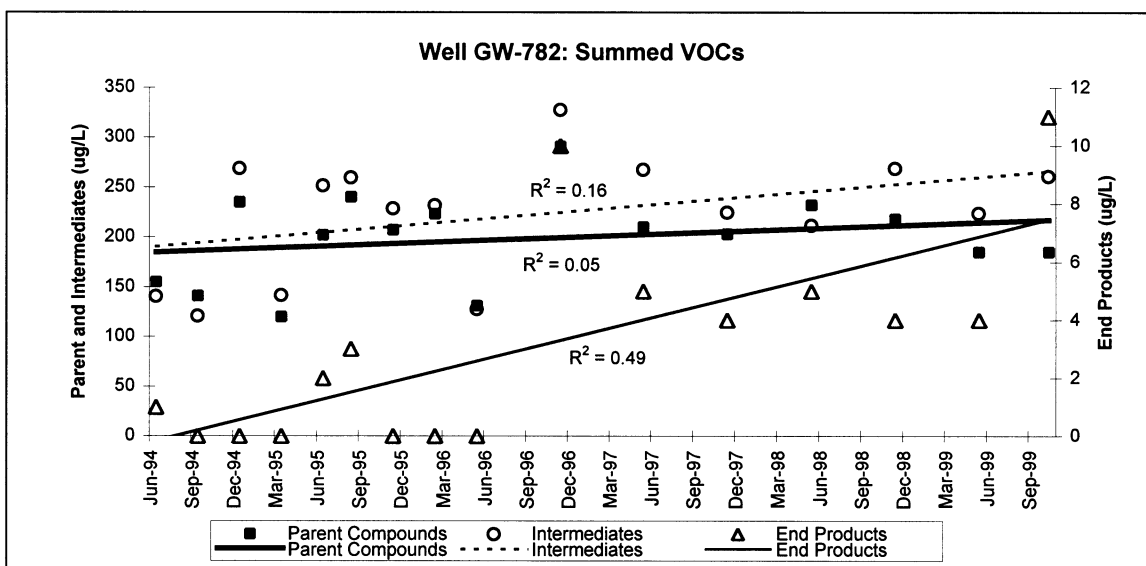
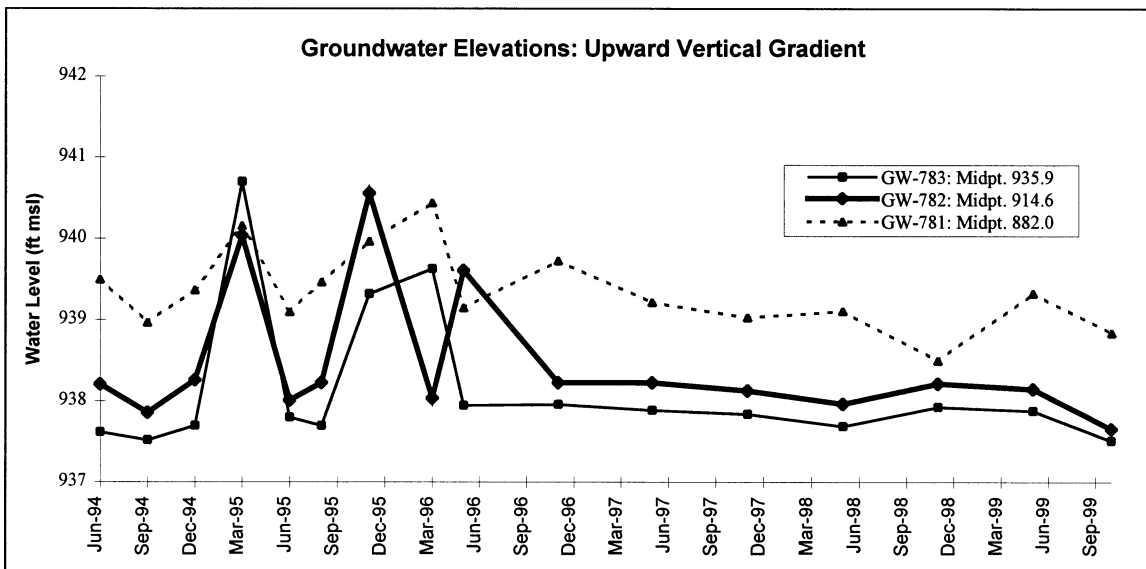




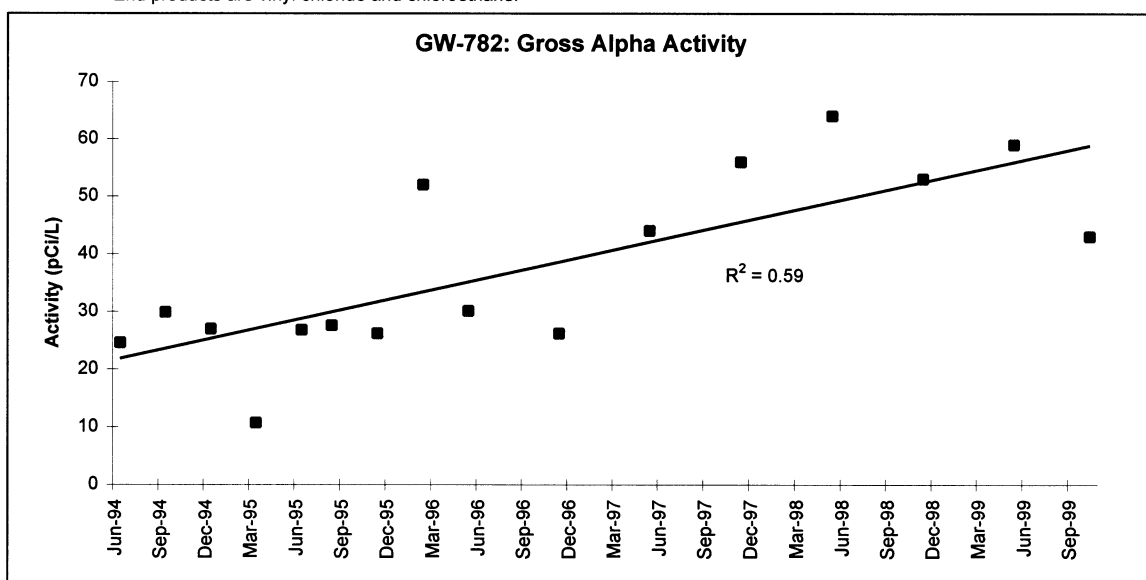
**Fig. 15. Increasing VOC concentrations in well GW-253.**



**Fig. 16. Increasing uranium concentrations and alpha activities in well GW-204.**



**Note:** Parent compounds are PCE and 1,1,1-TCA; Intermediates are TCE, 1,2-DCE, 1,1-DCE, and 1,1-DCA; End products are vinyl chloride and chloroethane.



**Fig. 17. Presampling water levels and increasing contaminant concentrations in well GW-782.**

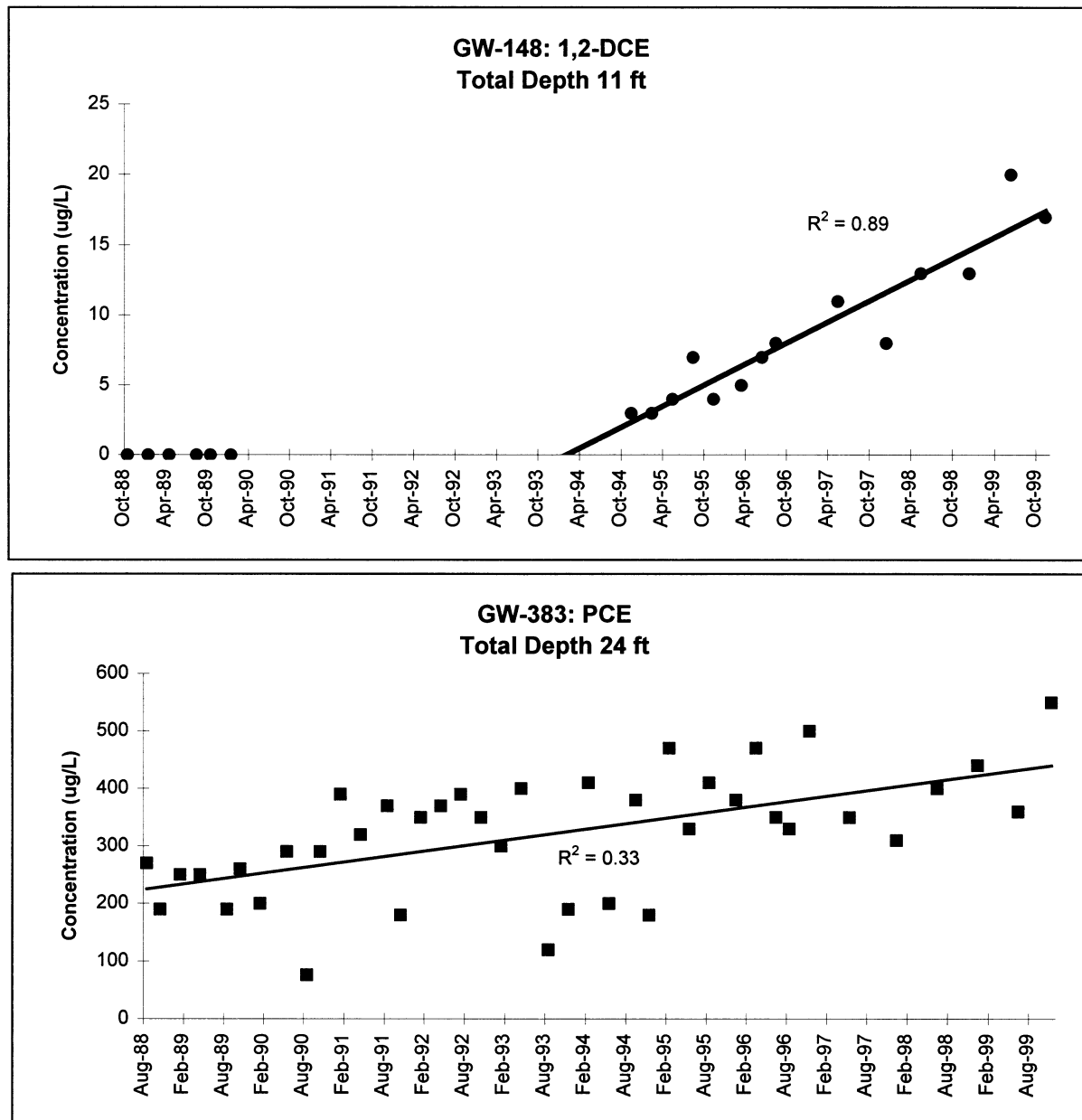


Fig. 18. Increasing VOC concentrations in wells GW-148 and GW-383.

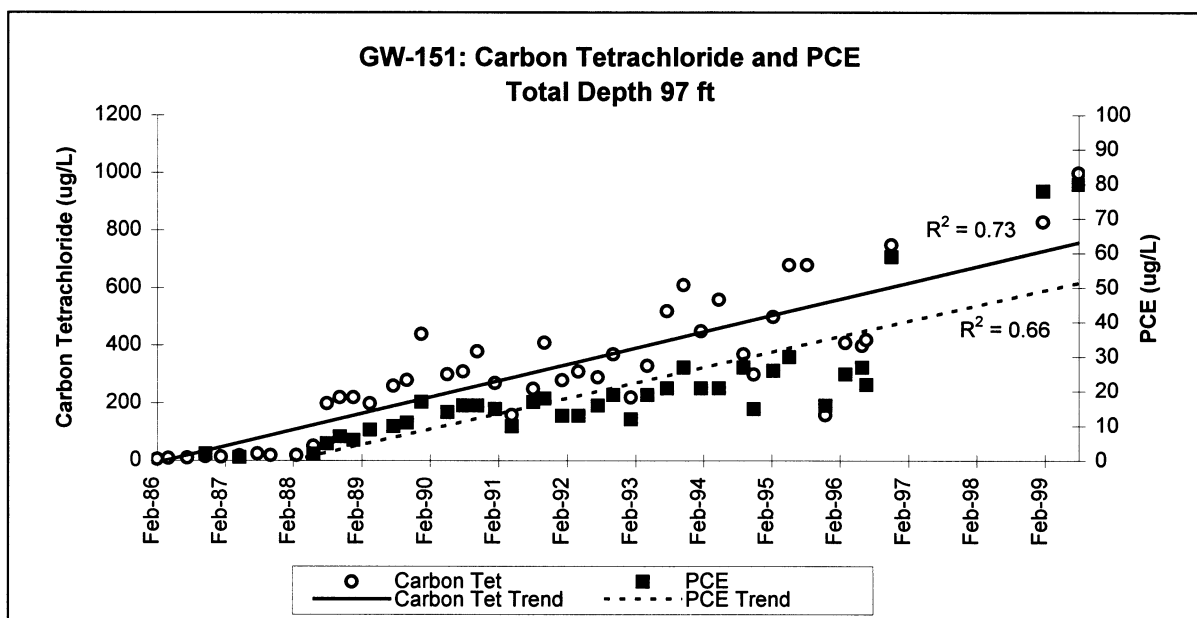
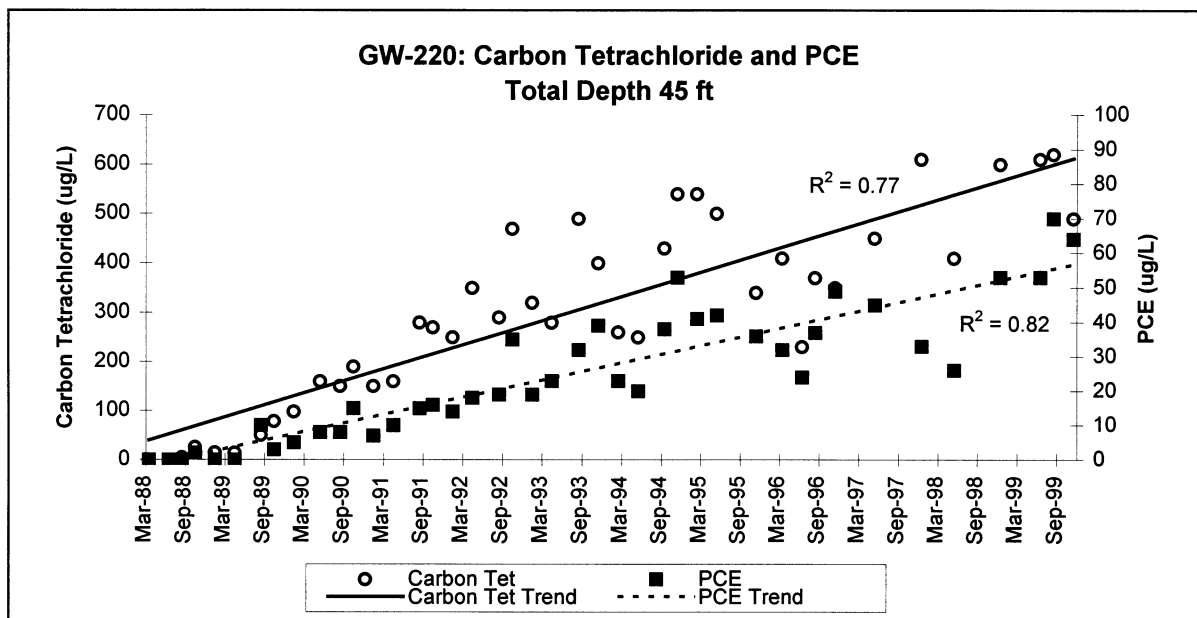
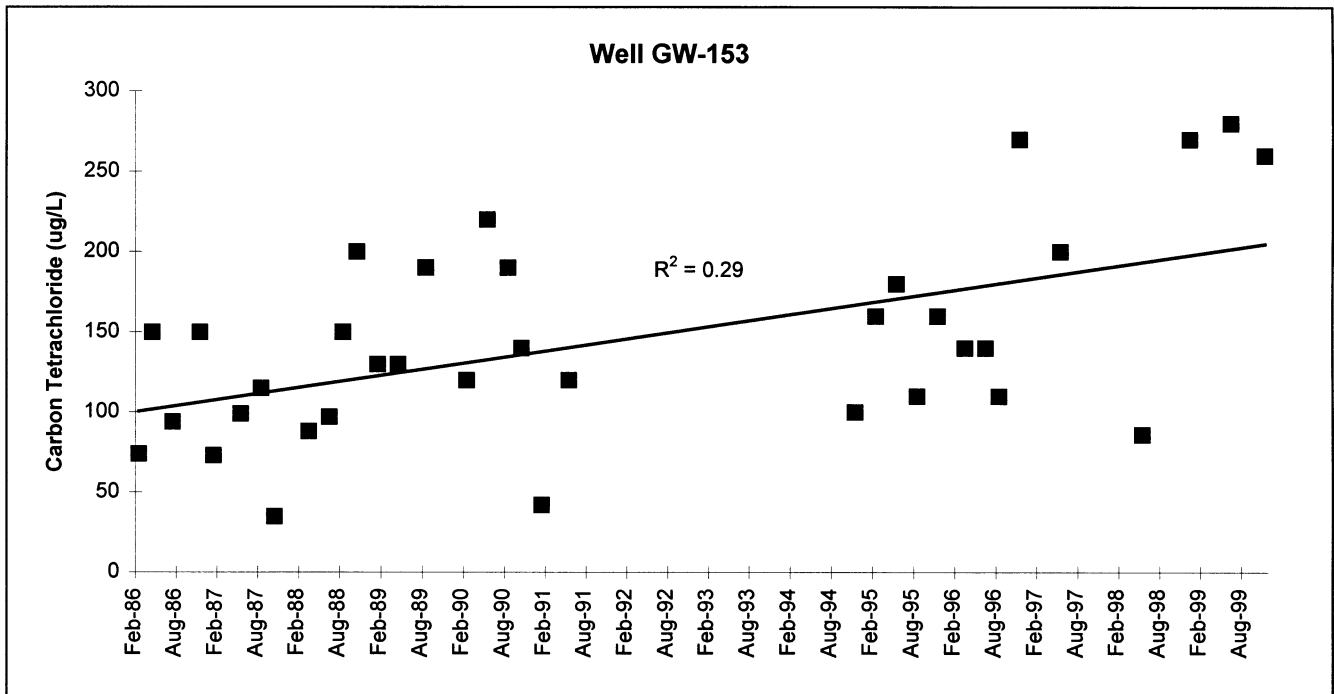
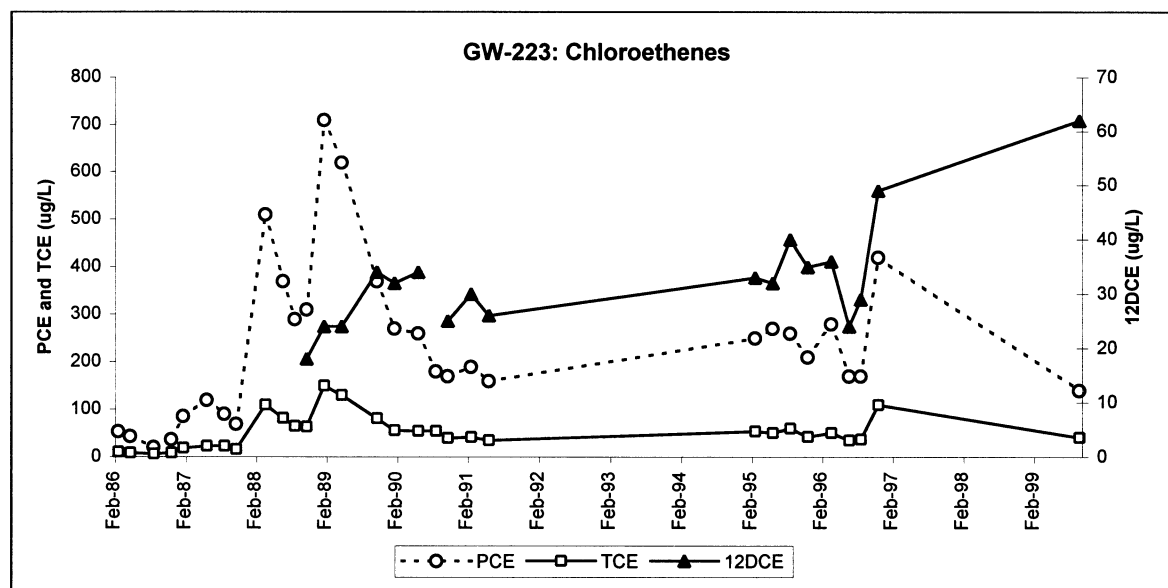
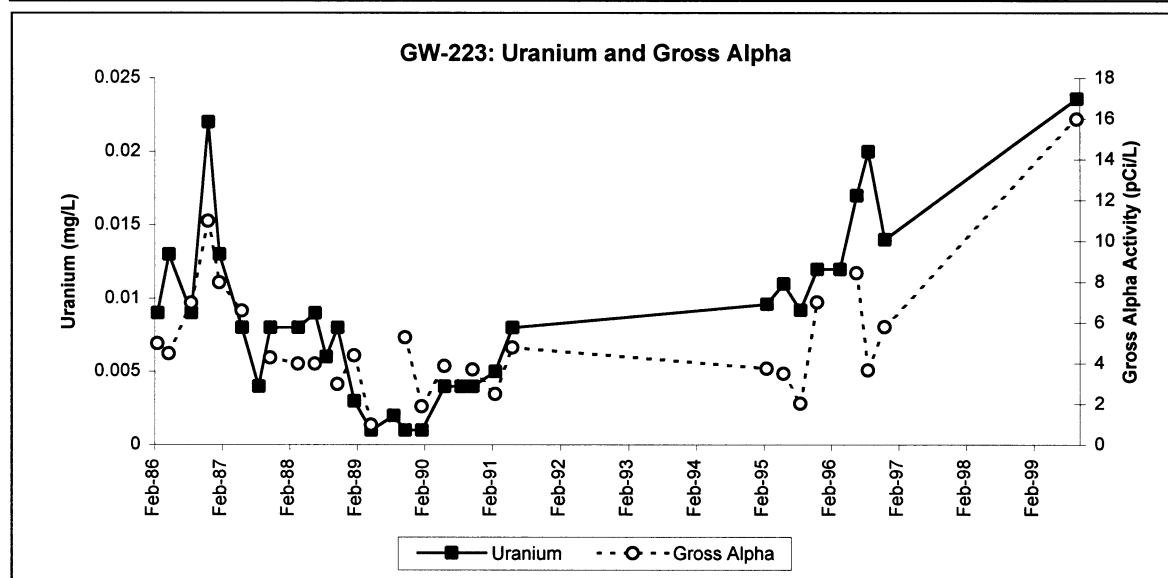
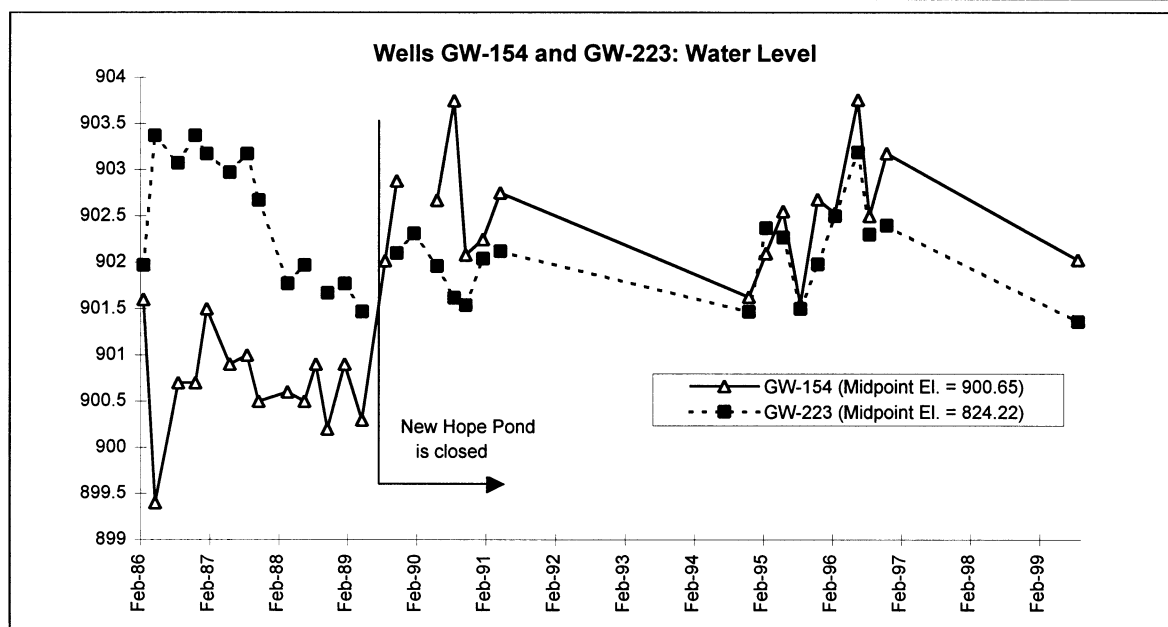


Fig. 19. Increasing VOC concentrations in wells GW-151 and GW-220.



**Fig. 20. Increasing carbon tetrachloride concentrations in well GW-153.**



**Fig. 21. Presampling water levels and increasing contaminant concentrations in well GW-223.**

## **APPENDIX B**

### **TABLES**



**Table B.1. Sources of groundwater contaminant signatures in the East Fork Regime**

Confirmed and Suspected Sources of Contamination <sup>1</sup>	Groundwater Contaminant Signature			
	Inorganics	Organics	Metals	Radionuclides
<b>WESTERN PLANT AREA</b>				
S-3 Ponds	Ž	Ž	Ž	Ž
Salvage Yard		Ž	Ž	Ž
Rust Garage Area		Ž		
Waste Coolant Processing Area		Ž	Ž	Ž
Building 9204-4		Ž	Ž	
Fire Training Facility		Ž		
Interim Drum Yard Vicinity		Ž		
S-2 Site	Ž	Ž	Ž	Ž
<b>CENTRAL PLANT AREA</b>				
Buildings 9201-4 and 9201-5		Ž	Ž	
Building 9731 Vicinity		Ž		Ž
Building 9212		Ž		
Tank 0134-U		Ž	Ž	Ž
Building 81-10			Ž	Ž
Buildings 9201-1 and 9201-2		Ž	Ž	
Tank 2331-U		Ž	Ž	
<b>EASTERN PLANT AREA</b>				
East End Garage (Building 9754-2)		Ž		
Uranium Oxide Vault			Ž	Ž
Wells GW-605 and GW-606 Vicinity				Ž
Former Oil Skimmer Basin			Ž	Ž
East End Carbon Tetrachloride Plume		Ž		
Building 9720-6		Ž		

**Note:**

- 1 Modified from: U.S. Department of Energy. 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*. Volume 3, Appendix D, Section D.5 - Nature and Extent of Site-Related Contaminants in Groundwater. The table includes contaminant sources relevant to discussions in this report.



**Table B.2. CY 1999 groundwater and surface water sampling locations and dates**

Evaluation Purpose <sup>1</sup>		DOE Order 5400.1A Exit Pathway/Perimeter Monitoring										
		DOE Order 5400.1A Surveillance Monitoring										
Sampling Point <sup>2</sup>	Sampling Location <sup>3</sup>	Y-12 Plant Area <sup>4</sup>			CY 1999 Sampling Date <sup>5</sup>							
		W	C	E	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter				
9201-5N-J4	B9201-5N		!		02/16/99	.	.	.	!			
9204-2E-NW	B9204-2E		!		02/23/99	.	.	.	!			
9204-2-NE	B9204-2		!		02/16/99	.	.	.	!			
9204-2-NW	B9204-2		!		02/16/99	.	.	.	!			
9204-4ELSU	B9204-4	!			02/17/99	.	.	.	!			
GHK2.51ESW	EXP-NPR				.	.	09/01/99	.		!		
GHK2.51WSW	EXP-NPR				.	.	09/01/99	.		!		
GW-108	S3	!			02/15/99	.	07/27/99	.	!			
GW-109	S3	!			.	.	09/02/99	.	!			
GW-131-01	EXP			!	.	06/14/99	.	.		!		
GW-131-04	EXP			!	.	06/15/99	.	.		!		
GW-131-08	EXP			!	.	06/16/99	.	.		!		
GW-131-12	EXP			!	.	06/16/99	.	.		!		
GW-131-15	EXP			!	.	06/17/99	.	.		!		
GW-131-21	EXP			!	.	<b>06/21/99D</b>	.	.		!		
GW-131-24	EXP			!	.	06/17/99	.	.		!		
GW-131-28	EXP			!	.	06/22/99	.	.		!		
GW-131-32	EXP			!	.	06/22/99	.	.		!		
GW-131-36	EXP			!	.	06/23/99	.	.		!		
GW-148	NHP			!	.	06/01/99	.	11/09/99	!			
GW-151	NHP			!	02/08/99	.	08/16/99	.		!		
GW-153	NHP			!	.	06/02/99	.	<b>11/09/99 D</b>	!			
GW-154	NHP			!	02/10/99	.	08/30/99	.	!			
GW-168	EXP			!	.	.	09/08/99	.	!			
GW-169	EXP-UV			!	02/08/99	.	09/01/99	.	!			
GW-170	EXP-UV			!	<b>02/08/99 D</b>	.	<b>08/31/99 D</b>	.	!			
GW-171	EXP-UV			!	02/11/99	.	08/25/99	.	!			
GW-172	EXP-UV			!	02/11/99	.	08/25/99	.	!			
GW-192	B4	!			.	05/26/99 A	.	11/01/99	!			
GW-193	T2331		!		02/16/99	.	07/20/99	.	!			
GW-204	T0134		!		.	.	09/13/99	.	!			
GW-207	EXP-SR			!	.	06/08/99	.	12/07/99		!		
GW-208	EXP-SR			!	.	06/08/99	.	11/17/99		!		

Table B.2 (continued)

Evaluation Purpose <sup>1</sup>		DOE Order 5400.1A Exit Pathway/Perimeter Monitoring								
		DOE Order 5400.1A Surveillance Monitoring								
		Y-12 Plant Area <sup>4</sup>			CY 1999 Sampling Date <sup>5</sup>					
Sampling Point <sup>2</sup>	Sampling Location <sup>3</sup>	W	C	E	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
GW-218	UOV		!		.	.	.	12/06/99 D	!	
GW-219	UOV		!		.	.	.	12/02/99	!	
GW-220	NHP			!	02/08/99	06/02/99	08/16/99	11/10/99		!
GW-223	NHP			!	.	.	09/07/99	.	!	
GW-230	EXP-UV			!	02/11/99 D	.	09/01/99	.	!	
GW-232	EXP-UV			!	02/08/99	.	09/01/99	.	!	
GW-251	S2	!			.	05/27/99 D	.	11/02/99	!	
GW-253	S2	!			02/08/99	.	08/24/99	11/8/99	!	
GW-337	WC	!			.	.	09/02/99	.	!	
GW-380	NHP			!	.	06/04/99	.	11/10/99	!	
GW-382	NHP			!	.	.	09/02/99	.	!	
GW-383	NHP			!	.	06/03/99	.	11/11/99	!	
GW-605	EXP-I			!	02/11/99	.	07/20/99	.	!	
GW-606	EXP-I			!	02/15/99 D	.	07/21/99	.	!	
GW-618	EXP-E	!			.	05/26/99	.	11/01/99	!	
GW-618	EXP-E	!			.	.	.	11/09/99	!	
GW-620	FTF	!			.	05/27/99	.	11/08/99	!	
GW-722-06	EXP-J			!	02/25/99 *	.	07/19/99	.		!
GW-722-10	EXP-J			!	03/01/99	.	07/20/99	.		!
GW-722-14	EXP-J			!	03/02/99	.	07/21/99	.		!
GW-722-17	EXP-J			!	03/04/99	.	07/22/99	.		!
GW-722-20	EXP-J			!	03/16/99	.	07/27/99 D	.		!
GW-722-22	EXP-J			!	03/17/99 D	.	07/22/99	.		!
GW-722-26	EXP-J			!	03/18/99	.	07/28/99	.		!
GW-722-30	EXP-J			!	03/23/99	.	07/28/99	.		!
GW-722-32	EXP-J			!	03/30/99	.	07/28/99	.		!
GW-722-33	EXP-J			!	03/30/99	.	07/28/99	.		!
GW-733	EXP-J			!	02/11/99	.	07/20/99	.		!
GW-735	EXP-J			!	.	06/15/99	.	11/29/99		!
GW-744	GRIDK1			!	.	06/09/99	.	11/17/99		!
GW-747	GRIDK2			!	.	06/09/99	.	11/29/99		!
GW-750	EXP-J			!	.	06/15/99	.	12/01/99 D		!
GW-762	GRIDJ3			!	02/09/99	.	08/24/99 D	.	!	
GW-763	GRIDJ3			!	.	06/01/99	.	11/08/99	!	

Table B.2 (continued)

Evaluation Purpose <sup>1</sup>		DOE Order 5400.1A Exit Pathway/Perimeter Monitoring								
		DOE Order 5400.1A Surveillance Monitoring								
		Y-12 Plant Area <sup>4</sup>			CY 1999 Sampling Date <sup>5</sup>					
Sampling Point <sup>2</sup>	Sampling Location <sup>3</sup>	W	C	E	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter		
GW-769	GRIDG3		!		.	04/20/99	.	10/21/99	!	
GW-770	GRIDG3		!		.	04/20/99	.	10/21/99	!	
GW-775	GRIDH3		!		.	04/22/99	.	10/27/99	!	
GW-776	GRIDH3		!		.	04/22/99	.	10/27/99	!	
GW-781	GRIDE3		!		.	05/25/99	.	10/26/99	!	
GW-782	GRIDE3		!		.	05/24/99 D	.	10/25/99	!	
GW-783	GRIDE3		!		.	05/24/99	.	10/25/99	!	
GW-788	GRIDF3		!		.	04/19/99	.	10/20/99	!	
GW-789	GRIDF3		!		.	04/19/99	.	10/20/99	!	
GW-791	GRIDD2		!		.	05/25/99	.	11/28/99 D	!	
GW-792	GRIDD2		!		.	05/25/99	.	11/28/99	!	
GW-816	EXP-SR			!	.	06/07/99 D	.	11/16/99		!
GW-820	B9201-2		!		.	.	09/10/99	.	!	
GW-832	NHP			!	02/09/99	.	08/31/99	.	!	
LRSPW	EXP-SW			!	.	06/03/99	.	11/15/99		!
NPR07.0SW	EXP-NPR				.	.	09/01/99	.		!
NPR10.0SW	EXP-NPR				.	.	DRY	.		!
NPR12.0SW	EXP-NPR				.	.	09/01/99	.		!
OF 195	EXP-SW	!			.	04/28/99	09/21/99	.		!
OF 200	EXP-SW		!		.	04/28/99	07/12/99 S	.		!
OF 221	EXP-SW	!			.	04/28/99	09/21/99	.		!
OF 225	EXP-SW	!			.	04/28/99	09/21/99	.		!
OF 51	EXP-SW		!		02/10/99	.	08/17/99	.		!
SCR7.1SP	EXP-UV			!	02/04/99	.	08/30/99	.		!
SCR7.18SP	EXP-UV			!	02/04/99	.	08/30/99	.		!
SCR7.8SP	EXP-UV			!	02/04/99	.	08/30/99	.		!
SP-17	EXP-SW			!	02/10/99	.	08/17/99	.		!
STATION 17	EXP-SW			!	02/12/99	04/28/99 *	07/12/99 S	.		!
STATION 8	EXP-SW		!		02/12/99	04/29/99	07/12/99 S	.		!

**Notes:**

- Although samples were collected from the sampling locations for a variety of monitoring purposes (e.g., RCRA), this report uses all of the monitoring results for DOE Order 5400.1A data evaluation purposes. The monitoring program for each location is provided in the CY 1999 GWMR (AJA Technical Services, Inc. 2000).

**Table B.2 (continued)**

**Notes (continued):**

- |   |  |
|---|--|
| 2 | <p>GHK - Gum Hollow Branch Kilometer (surface water sampling location)</p> <p>GW - Groundwater Monitoring Well; Westbay wells are GW-131 and GW-722</p> <p>LRSPW - Lake Reality Emergency Spillway (surface water sampling location)</p> <p>NPR - North of Pine Ridge near the Scarboro Community (surface water sampling location)</p> <p>OF - Storm drain outfall (surface water sampling location)</p> <p>SCR - Spring sampling location in Union Valley</p> <p>SP - Spring sampling location in the Y-12 Plant area</p> <p>STATION - Surface water sampling location in Upper East Fork Poplar Creek</p>   |
| 3 | <p>B4 - Beta-4 Security Pits</p> <p>B9201-2 - Building 9201-2</p> <p>B9201-5N - Building 9201-5 (sump sampling location)</p> <p>B9204-2 - Building 9204-2 (two sump sampling locations)</p> <p>B9204-2E - Building 9204-2E (sump sampling location)</p> <p>B9204-4 - Building 9204-4 (sump sampling location)</p> <p>EXP - Exit Pathway monitoring location:</p> <p>! -E, -I, or -J: Maynardville Limestone Picket monitoring well.</p> <p>! -NPR: Surface water station located north of Pine Ridge where drainage exits the Oak Ridge Reservation.</p> <p>! -SW: Onsite spring or surface water station</p> <p>! -SR: Along Scarboro Road in the gap through Pine Ridge</p> <p>! -UV: East of the Oak Ridge Reservation boundary in Union Valley</p> <p>FTF - Fire Training Facility</p> <p>GRID - Comprehensive Groundwater Monitoring Plan Grid Location</p> <p>NHP - New Hope Pond</p> <p>S2 - S-2 Site</p> <p>S3 - S-3 Ponds Site</p> <p>T0134 - Tank 0134-U</p> <p>T2331 - Tank 2331-U</p> <p>UOV - Uranium Oxide Vault</p> <p>WC - Waste Coolant Processing Area</p> |
| 4 | <p>W - Western, west of Y-12 Plant Grid east coordinate 55,000</p> <p>C - Central, between east coordinates 55,000 and 62,000</p> <p>E - Eastern, east of 62,000</p>   |
| 5 | <p>.</p> <p>D - Duplicate samples were collected.</p> <p>*</p> <p>A - Resampled on June 6, 1999 for anions analyses (GW-192).</p> <p>S - Two sets of samples were collected: a stormflow sample (within six hours after a 0.5-inch or more rain) and a baseflow sample (about 72 hours after the stormflow sample on 07/15/99).</p>  |

**Table B.3. Summary of CY 1999 VOC results**

Sampling Point			Summed VOCs <sup>3</sup>	Chlorinated Solvents <sup>4</sup>			Petroleum Hydrocarb. <sup>5</sup>	Misc. Compounds <sup>6</sup>
Identity <sup>1</sup>	Location <sup>2</sup>	Date		Ethenes	Ethanes	Methanes		
<b>WESTERN PLANT AREA</b>								
9204-4ELSU	B9204-4	02/17/99	<b>5</b>	5	0	0	0	0
GW-108	S3	02/15/99	<b>117</b>	2	0	92	2	21
GW-108	S3	07/27/99	<b>82</b>	4	0	75	0	3
GW-109	S3	09/02/99	<b>278</b>	178	0	29	0	71
GW-192	B4	05/26/99	<b>38</b>	36	2	0	0	0
GW-192	B4	11/01/99	<b>6</b>	6	0	0	0	0
GW-251	S2	05/27/99	<b>481</b>	460	0	21	0	0
GW-251	S2	11/02/99	<b>88</b>	83	0	5	0	0
GW-253	S2	02/08/99	<b>2,224</b>	2,101	0	123	0	0
GW-253	S2	08/24/99	<b>1,478</b>	1,397	0	74	2	5
GW-253	S2	11/08/99	<b>1,865</b>	1,773	0	92	0	0
GW-337	WCPA	09/02/99	<b>8,122</b>	7,793	310	0	0	19
GW-618	EXP-E	05/26/99	<b>46</b>	46	0	0	0	0
GW-618	EXP-E	11/01/99	<b>44</b>	44	0	0	0	0
GW-618	EXP-E	11/09/99	<b>46</b>	46	0	0	0	0
GW-620	FTF	05/27/99	<b>68</b>	62	0	0	6	0
GW-620	FTF	11/08/99	<b>19</b>	19	0	0	0	0
<b>CENTRAL PLANT AREA</b>								
9201-5N-J4	B9201-5N	02/16/99	<b>242</b>	232	10	0	0	0
9204-2-NE	B9204-2	02/16/99	<b>97</b>	67	21	5	0	4
9204-2E-NW	B9204-2	02/23/99	<b>21</b>	21	0	0	0	0
GW-193	T2331	02/16/99	<b>82</b>	0	0	0	82	0
GW-193	T2331	07/20/99	<b>50</b>	0	0	0	50	0
GW-204	CPT	09/13/99	<b>18</b>	18	0	0	0	0
GW-769	GRIDG3	04/20/99	<b>14</b>	5	0	9	0	0
GW-769	GRIDG3	10/21/99	<b>11</b>	4	0	7	0	0
GW-770	GRIDG3	04/20/99	<b>5</b>	0	0	5	0	0
GW-770	GRIDG3	10/21/99	<b>7</b>	0	0	7	0	0
GW-775	GRIDH3	04/22/99	<b>5</b>	5	0	0	0	0
GW-775	GRIDH3	10/27/99	<b>3</b>	3	0	0	0	0
GW-776	GRIDH3	04/22/99	<b>4</b>	4	0	0	0	0
GW-776	GRIDH3	10/27/99	<b>3</b>	3	0	0	0	0
GW-781	GRIDE3	05/25/99	<b>7</b>	7	0	0	0	0
GW-781	GRIDE3	10/26/99	<b>5</b>	5	0	0	0	0
GW-782	GRIDE3	05/24/99	<b>419</b>	296	117	0	6	0
GW-782	GRIDE3	10/25/99	<b>457</b>	274	183	0	0	0
GW-783	GRIDE3	05/24/99	<b>29</b>	24	3	2	0	0
GW-783	GRIDE3	10/25/99	<b>86</b>	75	11	0	0	0
GW-789	GRIDF3	04/19/99	<b>1</b>	0	0	1	0	0
GW-791	GRIDD2	05/25/99	<b>222</b>	222	0	0	0	0
GW-791	GRIDD2	11/28/99	<b>73</b>	73	0	0	0	0

Table B.3 (continued)

Sampling Point			Summed VOCs <sup>3</sup>	Chlorinated Solvents <sup>4</sup>			Petroleum Hydrocarb. <sup>5</sup>	Misc. Compounds <sup>6</sup>
Identity <sup>1</sup>	Location <sup>2</sup>	Date		Ethenes	Ethanes	Methanes		
CENTRAL PLANT AREA (continued)								
GW-792	GRIDD2	05/25/99	7	7	0	0	0	0
GW-792	GRIDD2	11/28/99	5	5	0	0	0	0
GW-820	B9201-2	09/10/99	2,840	2,840	0	0	0	0
EASTERN PLANT AREA								
GW-148	NHP	06/01/99	20	20	0	0	0	0
GW-148	NHP	11/09/99	17	17	0	0	0	0
GW-153	NHP	06/02/99	328	9	0	295	0	24
GW-153	NHP	11/09/99	306	5	0	274	0	27
GW-223	NHP	09/07/99	243	243	0	0	0	0
GW-380	NHP	06/04/99	2	0	0	2	0	0
GW-382	NHP	09/02/99	2,956	134	2	2,820	0	0
GW-383	NHP	06/03/99	665	665	0	0	0	0
GW-383	NHP	11/11/99	850	850	0	0	0	0
GW-605	EXP-I	02/11/99	72	50	0	22	0	0
GW-605	EXP-I	07/20/99	148	112	0	36	0	0
GW-606	EXP-I	02/15/99	322	7	0	312	3	0
GW-606	EXP-I	07/21/99	453	8	0	442	3	0
GW-762	GRIDJ3	02/09/99	1,462	1,462	0	0	0	0
GW-762	GRIDJ3	08/24/99	1,863	1,849	14	0	0	0
GW-763	GRIDJ3	06/01/99	48	48	0	0	0	0
GW-832	NHP	02/09/99	55	6	0	49	0	0
GW-832	NHP	08/31/99	55	6	0	49	0	0
UNION VALLEY								
GW-169	EXP-UV	02/08/99	3	3	0	0	0	0
GW-169	EXP-UV	09/01/99	1	1	0	0	0	0
GW-170	EXP-UV	02/08/99	78	7	0	71	0	0
GW-170	EXP-UV	08/31/99	47	4	0	43	0	0
GW-230	EXP-UV	02/11/99	15	14	0	0	1	0
GW-230	EXP-UV	09/01/99	7	5	0	2	0	0
SCR7.18SP	EXP-UV	02/04/99	1	0	1	0	0	0
SCR7.18SP	EXP-UV	08/30/99	3	0	3	0	0	0
SCR7.1SP	EXP-UV	08/30/99	7	0	4	3	0	0
SCR7.8SP	EXP-UV	02/04/99	4	2	2	0	0	0
EXIT PATHWAY/PERIMETER MONITORING								
GW-151	NHP	02/08/99	973	103	0	870	0	0
GW-151	NHP	08/16/99	1,226	96	0	1,130	0	0
GW-220	NHP	06/02/99	712	69	0	643	0	0
GW-220	NHP	08/16/99	751	88	0	663	0	0
GW-220	NHP	11/10/99	611	81	0	530	0	0



**Table B.3 (continued)**

Sampling Point			Summed VOCs <sup>3</sup>	Chlorinated Solvents <sup>4</sup>			Petroleum Hydrocarb. <sup>5</sup>	Misc. Compounds <sup>6</sup>
Identity <sup>1</sup>	Location <sup>2</sup>	Date		Ethenes	Ethanes	Methanes		
EXIT PATHWAY/PERIMETER MONITORING (continued)								
GW-722-10	EXP-J	03/01/99	52	8	0	44	0	0
GW-722-10	EXP-J	07/20/99	59	7	0	52	0	0
GW-722-14	EXP-J	03/02/99	621	47	2	567	0	5
GW-722-14	EXP-J	07/21/99	658	40	2	610	0	6
GW-722-17	EXP-J	03/04/99	820	66	0	747	0	7
GW-722-17	EXP-J	07/22/99	780	43	0	731	0	6
GW-722-20	EXP-J	03/16/99	326	49	0	273	0	4
GW-722-20	EXP-J	07/27/99	272	33	0	236	0	3
GW-722-22	EXP-J	03/17/99	456	37	0	416	0	3
GW-722-22	EXP-J	07/22/99	547	36	0	506	0	5
GW-722-26	EXP-J	03/18/99	4	0	0	0	4	0
GW-722-26	EXP-J	03/23/99	10	0	0	0	10	0
GW-722-32	EXP-J	07/28/99	1	0	0	1	0	0
GW-722-33	EXP-J	07/28/99	1	0	0	1	0	0
GW-733	EXP-J	02/11/99	10	0	0	9	1	0
GW-733	EXP-J	07/20/99	11	0	0	11	0	0
LRSPW	EXP-SW	06/03/99	64	7	0	57	0	0
LRSPW	EXP-SW	11/15/99	39	5	0	34	0	0
OF 51	UEFPC	02/10/99	17	14	1	2	0	0
OF 51	UEFPC	08/17/99	34	29	1	4	0	0
OF 200	UEFPC	07/12/99	3	3	0	0	0	0
OF 200	UEFPC	07/15/99	8	3	0	5	0	0
STATION 8	UEFPC	02/12/99	5	1	0	4	0	0
STATION 8	UEFPC	04/29/99	4	2	0	2	0	0
STATION 8	UEFPC	07/12/99	4	2	0	2	0	0
STATION 8	UEFPC	07/15/99	5	0	0	5	0	0
STATION 17	UEFPC	02/12/99	2	0	0	2	0	0
STATION 17	UEFPC	04/29/99	2	1	0	1	0	0
STATION 17	UEFPC	07/15/99	3	0	0	3	0	0

**Notes:**

- 1 GW - Groundwater Monitoring Well; GW-131 and GW-722 are Westbay wells  
 LRSPW - Lake Reality Emergency Spillway (surface water station)  
 OF - Outfall (surface water station)

**Table B.3 (continued)**

**Notes:** (continued)

- 2
  - B4 - Beta-4 Security Pits
  - B9201-2 - Building 9201-2
  - B9201-5N - Building 9201-5N (sump sampling location)
  - B9204-2 - Building 9204-2 (two sump sampling locations)
  - B9204-2E - Building 9204-2E (sump sampling location)
  - B9204-4 - Building 9204-4 (sump sampling location)
  - EXP - Exit Pathway monitoring location:
    - ° -E, -I, or -J: Maynardville Limestone Picket monitoring well.
    - ° -SW: Onsite spring or surface water station
    - ° -SR: Along Scarboro Road in the gap through Pine Ridge
    - ° -UV: East of the Oak Ridge Reservation boundary in Union Valley
  - FTF - Fire Training Facility
  - GRID - Comprehensive Groundwater Monitoring Plan Grid Location
  - NHP - New Hope Pond
  - S2 - S-2 Site
  - S3 - S-3 Ponds Site
  - T0134 - Tank 0134-U
  - T2331 - Tank 2331-U
  - UOV - Uranium Oxide Vault
  - WC - Waste Coolant Processing Area
- 3 Sum of all VOCs, in micrograms per milliliter. Only results with a sum greater than zero are shown on the table. Anomalous results (e.g., carbon disulfide) and/or artifacts (e.g., acrylonitrile) are excluded.
- 4
  - Ethenes = Summed chloroethenes (PCE, TCE, 1,2-DCE, 1,1-DCE, 1,1-DCE, vinyl chloride)
  - Ethanes = Summed chloroethanes (1,1,1-TCA, 1,1-DCA, chloroethane)
  - Methanes = Summed chloromethanes (carbon tetrachloride, chloroform, methylene chloride)
- 5 Petroleum hydrocarbons = summed benzene, ethylbenzene, toluene, xylenes (dimethylbenzene), chlorobenzene, and styrene (degradation product of ethylbenzene).
- 6 Miscellaneous compounds: Western and Central Plant Areas = primarily acetone; Eastern Plant Area = bromomethanes at well GW-153 and trichlorofluoromethane at well GW-722 (ports 14, 17 , 20, and 22).

**Table B.4. Long-term contaminant trends observed  
at monitoring locations sampled in CY 1999**

CY 1999 Sampling Location <sup>1</sup>	Contaminant Type and Long-Term Trend <sup>2</sup>						
	Inorganics <sup>3</sup>		VOCs <sup>4</sup>			Radioactivity <sup>5</sup>	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
<b>Western Plant Area</b>							
9204-4ELSU	"	"	"	.	.	.	.
GW-108	—	"	.	.	[	.	[
GW-109	"	.	"	.	—	.	—
GW-192	.	.	"	.	.	.	.
GW-251	—	.	"	.	"	.	.
GW-253	"	.	[	.	"	"	.
GW-337	.	.	—	—	.	.	.
GW-618	.	.	"	.	.	.	.
GW-620	"	.	—	.	.	.	.
<b>OF 195</b>	"	.	.	.	.	"	"
<b>OF 221</b>	"	.	.	.	.	"	"
<b>OF 225</b>	"	.	.	.	.	"	"
<b>Central Plant Area</b>							
9201-5N-J4	"	.	"	"	.	.	.
9204-2-NE	.	.	"	"	"	.	.
9204-2-NW	"	.	.	.	.	.	.
9204-2E-NW	.	.	"	.	.	.	.
GW-193	"	.	.	.	.	.	.
GW-204	.	[	"	.	.	[	.
GW-218	"	.	.	.	.	"	"
GW-219	.	"	.	.	.	"	"
GW-769	.	.	"	.	"	.	.
GW-770	.	.	.	.	"	.	.
GW-775	.	.	"	.	.	.	.
GW-776	"	.	.	.	.	.	.
GW-781	.	.	"	.	.	.	.
GW-782	.	.	[	[	.	[	.
GW-783	"	.	"	"	.	.	.
GW-788	.	.	.	.	.	.	.
GW-789	.	.	.	.	.	.	.
GW-791	.	.	—	.	.	.	.
GW-792	"	.	"	.	.	.	.
GW-820	.	.	"	.	.	.	.
<b>OF 51</b>	"	.	"	.	"	.	.
<b>OF 200</b>	"	.	"	.	"	"	.
<b>STATION 8</b>	"	.	.	.	"	"	.

Table B.4 (continued)

CY 1999 Sampling Location <sup>1</sup>	Contaminant Type and Long-Term Trend <sup>2</sup>						
	Inorganics <sup>3</sup>		VOCs <sup>4</sup>			Radioactivity <sup>5</sup>	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
<b>Eastern Plant Area</b>							
GW-131-01	.	.	.	.	.	.	.
GW-131-04	.	.	.	.	.	.	.
GW-131-08	.	.	.	.	.	.	.
GW-131-12	.	.	.	.	.	.	.
GW-131-15	.	.	.	.	.	.	.
GW-131-21	.	.	.	.	.	.	.
GW-131-24	.	.	.	.	.	.	.
GW-131-28	.	.	.	.	.	.	.
GW-131-32	.	.	.	.	.	.	.
GW-131-36	.	.	.	.	.	.	.
GW-148	.	.	[	.	.	.	.
GW-151	"	.	[	.	[	.	.
GW-153	.	.	"	.	[	.	.
GW-154	.	—	.	.	.	"	—
GW-168	.	.	.	.	.	.	.
GW-207	.	.	.	.	.	.	.
GW-208	.	.	.	.	.	.	.
GW-220	.	.	[	.	[	.	.
GW-223	.	[	[	.	—	"	.
GW-380	"	.	.	.	.	.	.
GW-382	"	.	"	.	"	.	.
GW-383	.	.	[	.	.	.	.
GW-605	.	"	"	.	—	"	.
GW-606	"	.	"	.	—	.	.
GW-722-06	.	.	.	.	.	.	.
GW-722-10	.	.	"	.	"	.	.
GW-722-14	"	.	"	.	"	.	.
GW-722-17	"	.	"	.	"	.	.
GW-722-20	.	.	"	.	"	.	.
GW-722-22	"	.	"	.	"	.	.
GW-722-26	.	.	.	.	.	.	.
GW-722-30	.	.	.	.	.	.	.
GW-722-32	.	.	.	.	.	.	.
GW-722-33	.	.	.	.	.	.	.
GW-733	.	.	.	.	—	.	.
GW-735	.	.	.	.	.	.	.
GW-744	.	.	.	.	.	.	.
GW-747	.	.	.	.	.	.	.
GW-750	.	.	.	.	.	.	.
GW-762	.	.	"	"	.	.	.
GW-763	.	.	"	.	.	.	.
GW-816	.	.	.	.	.	.	.
GW-832	"	.	"	.	"	.	.
LRSPW	"	.	"	.	"	.	.
SP-17	"	.	.	.	.	.	.

**Table B.4 (continued)**

CY 1999 Sampling Location <sup>1</sup>	Contaminant Type and Long-Term Trend <sup>2</sup>						
	Inorganics <sup>3</sup>		VOCs <sup>4</sup>			Radioactivity <sup>5</sup>	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
<b>Union Valley</b>							
GW-169	.	.	.	.	.	.	.
GW-170	.	.	"	.	"	.	.
GW-171	.	.	.	.	.	.	.
GW-172	.	.	.	.	.	.	.
GW-230	.	.	"	.	.	.	.
GW-232	.	.	.	.	.	.	.
SCR7.1SP	.	.	.	.	.	.	.
SCR7.18SP	.	.	.	.	.	.	.
SCR7.8SP	.	.	.	.	.	.	.

**Notes:**

- 1 All CY 1999 sampling locations are included on the table. The exit pathway/perimeter monitoring locations are in bold typeface.
- 2 Trend types were interpreted from data tables or plots of concentration changes over time.
  - .
  - "
  - 
  - [
- 3 CY 1999 nitrate concentration greater than or equal to 1 mg/L.  
Total uranium concentration greater than or equal to 0.01 mg/L.
- 4 Summed CY 1999 concentration of a solvent group greater than or equal to 5 : g/L.
  - Ethenes = Summed chloroethenes (PCE, TCE, 12DCE, 11DCE, 11DCE, vinyl chloride)
  - Ethanes = Summed chloroethanes (111TCA, 11DCA, chloroethane)
  - Methanes = Summed chloromethanes (carbon tetrachloride, chloroform, methylene chloride)
- 5 Maximum CY 1999 gross alpha activity greater than or equal to 15 pCi/L.  
Maximum CY 1999 gross beta activity greater than or equal to 50 pCi/L.

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